#123 January 1987

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Dr. Dobb's Journal of Software Tools

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ANNUAL 68K ISSUE

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Mac and Amiga Interface Programming

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The Bandwidth Bottleneck

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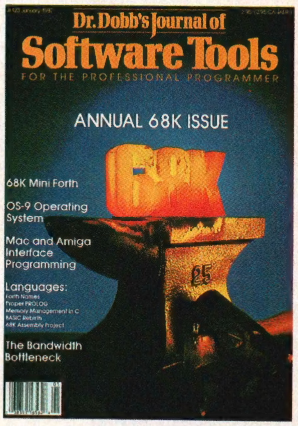


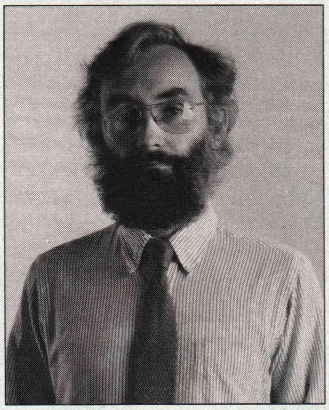
About the Cover
Motorola has just forged the 68030. Is it as hot as it seems?

This Issue
In the beginning there were the 8080 and the 6502—programmers chose their weapons and the battle lines were drawn. A few years later, Motorola gave the "sixers" more power when it introduced its 680xx line of chips. Today there is a wide range of powerful 680xx machines—and some very interesting rumors about the future. This month we survey the 680xx family and examine a modular, multitasking operating system, a 68K Forth-like interpreter, and the challenges of creating Amiga- and Mac-like user interfaces.

Next Issue
The choice of a text editor is based on many highly subjective considerations as well as some "hard" pragmatic requirements. In February, we'll present an overview of the various elements involved in that choice and let you hear what some programmers have to say about their favorite and least favorite editors.

—bandwidth topic
—entry point

EDITORIAL



Here's some of what we have planned for *DDJ*'s twelfth year.

In a series of short reports, contributing editor Namir Shammas will examine the state of the BASIC language in 1987. Yes, BASIC. *DDJ* is hardly a beginner's magazine, but if the beginner's language has grown up to long pants, as some claim, we should all know about it.

Then again, each of us is a novice in some area. Realizing this, *DDJ* will use the icon at the beginning of this paragraph to flag certain features as entry points: items such as Allen Holub's Flotsam and Jetsam in this issue, from which the less experienced programmer can learn useful techniques or gain familiarity with more technical subjects.

There are a lot of ways to write about artificial intelligence, nearly all bad. Our new column on alternative programming paradigms (it starts next month) will avoid them all as it examines such topics as knowledge-based programming, logic programming, and object-oriented programming from an experienced software designer's perspective. Contributing editor Ernie Tello writes, lectures, and consults in this area and promises to take us beyond the fields we know.

And we're going to attack the bandwidth problem.

DDJ was born to shoehorn BASIC into the hypomnemonic personal computers of 1976. In a sense, the Cain/Hendrix versions of Small-C published in *DDJ* over the succeeding years addressed this same problem of cramming programming power into micro memory. You could say that's been the charter of the magazine, and on one level it will continue to be our focus. But nobody today needs another Tiny BASIC or Small-C. Developments like the Intel 80386 processor lift the lid of a different box of programming problems. One is the efficient transmission of information over limited channels.

Bandwidth is already an issue in graphics output: Microsoft Windows never made sense on 8088 machines and the PARC interface overwhelmed the original 128K Mac. Adequate memory and processor power make a big difference, but they may ultimately just move the bottleneck to the IC level.

Bandwidth becomes more of an issue in mass storage as storage becomes more massive. Once we learn what to do with CD-ROMs, retrieving information efficiently from them will require more than increased speed of transmission.

The potential bandwidth crunch in telecommunications and remote database access is obvious, but when LANs start proliferating, so will in-house bandwidth competition.

Approaches to the bandwidth crunch can range from clever data-compression algorithms to systems that form hypotheses about incoming data and acquire just enough data to confirm or reject the hypotheses. As access to information becomes more technically problematic, it will also take on sociopolitical dimensions; for example, public libraries are becoming measurably less public as they subscribe to commercial information-provider services and pass the costs on to their patrons. We'll delve into the technology for dealing with the bandwidth crunch while trying to see its potential social consequences.

Bandwidth-related items will be flagged with the icon at the end of this line.

Michael Swaine

Michael Swaine
editor-in-chief

Dr. Dobb's Journal of Software Tools

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AZTEC C — The C for Microcomputers

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, Commodore, XENIX, ROM, and Cross Development systems

MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

Manx Aztec C86

"A compiler that has many strengths . . . quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
Large Memory Model	Intel Object Option
Z (vi) Source Editor -c	CP/M-86 Library -c
ROM Support Package -c	INTEL HEX Utility -c
Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
Aztec C86-a Apprentice System	**$49**

All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

C-tree $395	**Greenleaf $185**
PHACT $250	**PC-lint $98**
HALO $250	**Amber Windows $59**
PRE-C $395	**Windows for C $195**
WindScreen $149	**FirsTime $295**
SunScreen $99	**C Util Lib $185**
PANEL $295	**Plink-86 $395**

MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible . . . documentation is excellent . . . the shell a pleasure to work in . . . blows away the competition for pure compile speed . . . an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C	Creates Clickable Applications
Macro Assembler	Mouse Enhanced SHELL
Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
Librarian	Clear Detailed Documentation
Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

Aztec C68k-c Commercial System	**$499**
Aztec C68d-d Developer's System	**$299**
Aztec C68k-p Personal System	**$199**
C-tree database (source)	**$399**
AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3	**$399**
Aztec C65-d Apple DOS 3.3	**$199**
Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST, Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

HOSTS: VAX UNIX ($3000), PDP-11 UNIX ($2000), MS-DOS ($750), CP/M ($750), MACINTOSH ($750), CP/M-68k ($750), XENIX ($750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

The first TARGET is included in the price of the HOST system. Additional TARGETS are $300 to $500 (non VAX) or $1000 (VAX).

Call Manx for information on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

CP/M, Radio Shack, 8080/8085/Z80 ROM

Manx Aztec CII

"I've had a lot of experience with different C compilers, but the Aztec C80 Compiler and Professional Development System is the best I've seen."

80-Micro, December, 1984, John B. Harrell III

Aztec C II-c (CP/M & ROM)	**$349**
Aztec C II-d (CP/M)	**$199**
C-tree database (source)	**$399**
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Aztec C80-d (TRS-80 3 & 4)	**$199**

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30 Day Guarantee

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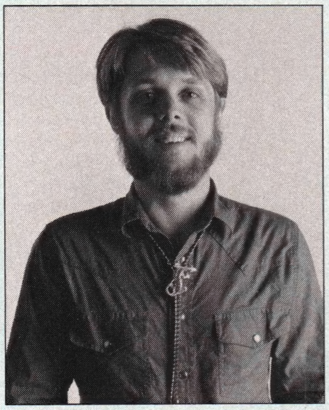
RUNNING LIGHT



What is the logical end point of the current trend toward smaller and smaller chip components? How soon will it be reached, and how reliable will the components be at that level? These questions are being addressed by a totally new branch of science, one that combines the disciplines of chemistry, physics, biology, computer science, and mathematics. The new field, called nanotechnology, concerns itself with devices that are several orders of magnitude smaller than current microcircuitry—components made up of individual atoms and molecules carefully bonded one by one. This may seem too farfetched to expect to see it in our lifetimes, but we're much, much closer than that. Several recent developments have suddenly elevated nanotechnology from a pipe dream to a bona fide discipline. I recently attended a seminar at which the field's most vocal advocate, Eric Drexler, spoke eloquently about nanotechnology. He actually laid out the design (on an atom-by-atom scale) of a working nanocomputer, smaller than a virus particle, along with all its support devices. I'm excited by the potential of such incredibly small, fast devices, and I'd love to hear from any of you who are working in this new field.

We've received excellent responses to our October 1986 issue, which focused on the 80386 and its family. This month we focus on the other side, the sixers. (If you're a 680xx programmer, you're probably a sixer.) We start with an overview of the 68000 line—where it has been, where it is now, and where it might be going. As more information becomes available on the 68040 (and beyond), we'll keep you up to date.

Yates Fletcher has written a Forth-like interpreter for the 68000 that he calls FLINT. His article in this issue describes it in detail and offers some interesting insight into what makes threaded interpreters so efficient. Also in this issue, Brian Capouch takes a look at the OS-9 operating system from Microware. OS-9 shows promise as a standard for 68K development work, and Brian explains why. Jan Harrington's article about Amiga gadgets and Macintosh buttons is one of the clearest comparisons I've seen of the different programming styles required on the two machines.

This month I begin what I hope will be a series of essays on the design of an interpreted language for the 68000. I'm interested in your comments and criticism.

Last July, in our annual Forth issue, we published an article about a Forth-driven robot that dives into the ocean, records oceanic data, and then pops up to send the data home via satellite. This July we'd like to focus on embedded systems of that sort—programs that reside inside autonomous devices. If you're working on such a device, we'd like to hear from you.

Bela Lubkin has joined Levi Thomas and Ray Duncan as a sysop on our CompuServe SIG (DDJFORUM) and has been stirring things up quite nicely. You will doubtless see his name on many a message in DDJ On Line.

Finally, I'd like to thank Jerry Houston, Roger Dunn, John Berry, Charles Marslett, and Wayne Vucenic for their help with Table 2 on page 18.

Nick Turner
editor

ARCHIVES

The 68000 et Famille

[A small boy, Oliver Wendall Jones, is sitting on Santa's lap reciting his Christmas wish list.]

Oliver: "That's the 32-bit MC68000 microprocessor . . . not to be confused with. . . ."

Santa: "The 16-bit 8088. Total garbage, El Stinko."—*Bloom County (comic strip), Berke Breathed, December 12, 1985.*

"Tom Pittman, the implementor of the $5/copy version of Tiny BASIC for the 6800 and 650x is now offering an experimenter's kit for those folks who want to modify and extend his Tiny BASIC. The kit includes an assembled source listing for the IL (Intermediate Language), an IL assembler written in Tiny BASIC, a detailed description of the virtual machine implemented by the IL, instructions for incorporating a new IL into the Tiny BASIC system, and finally some practical hints about debugging and extending the system. The cost is $10 from Itty Bitty Computers."—DDJ, *March 1977.*

Flak from Our Readers

"A language design frequency of almost one Tiny BASIC version per month is certainly impressive. Programmers ought to have realized that God invented many different laguages in Babylon not to enjoy but to punish mankind, and, after all, he never intended implementing all of them for the 8080. So why not write—and, if necessary, publish—programs in an informal, ad hoc language fitting to the problem, not the computer?"—*Thomas Alexander Matzner, letter to the editor,* DDJ, *March 1977.*

"[You write 'em; we'll publish (maybe).]"—*editorial reply to the above,* DDJ, *March 1977.*

Ten Years Ago in *DDJ*

"Why bother with a multi-tasking operating system on a 'personal' computer? Let's daydream for a moment. Wouldn't it be nice to be able to start a lengthy listing on our hardcopy device; while that was running, start an assembly of a large program; and then go about editing the source for another program from our softcopy terminal? That's EXACTLY what you can do with a multi-tasking system."—*Jim Warren,*DDJ, *January 1977.*

"I would like to particularly applaud Dick [Wilcox]'s position regarding low-cost distribution of software for not-for-profit use. He is recognizing and adjusting to the realities of the new world of personal computing in a manner that I feel is fair and reasonable for everyone concerned."—*Jim Warren,* DDJ, *January 1977.*

DR. DOBB'S JOURNAL of COMPUTER Calisthenics & Orthodontia
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DR. DOBB'S, August 1986

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Five Memory Models Supported

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Memory Models

Model	Code	Data
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Program	1M	64k
Data	64k	1M
Large	1M	1M

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Complete Library Includes Source Code

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Concise Documentation Included

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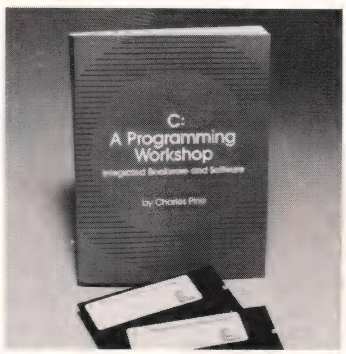

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ADAM GREEN, INFO WORLD
January 27, 1986

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Magazine Reviewers Shocked by DATALIGHT'S PERFORMANCE...

"Reviewing this compiler was quite a surprise for us. For such a low price, we were expecting a "lightweight" compiler. What we got was a package that is as good as or better than most of the "heavyweights." DATALIGHT C implements a complete C language. It also compiles quickly, doesn't take up much disk space, and looks impressive in the benchmarks."

DR. DOBB'S, August 1986

"This is a sharp compiler! ...what is impressive is that DATALIGHT not only stole the compile time show completely, but had the fastest Fibonacci executable time and had excellent object file sizes to boot!"

Chris Skelly, COMPUTER LANGUAGE
February 1986

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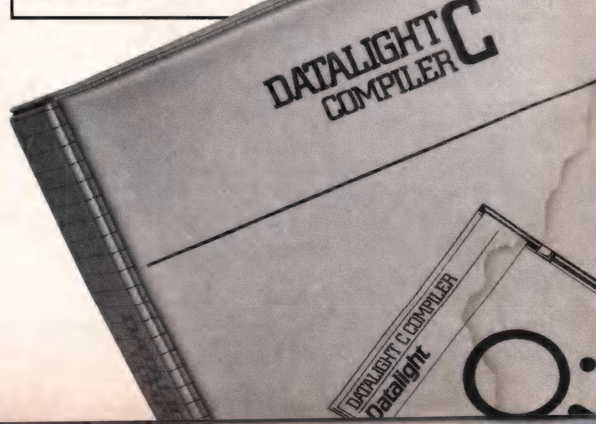
- Full UNIX System 5 C language plus ANSI extensions.
- Fast/tight code via powerful optimizations including common sub-expression elimination.
- DLC one step compile/link program.
- Multiple memory model support.
- UNIX compatible library with PC functions.
- Compatible with DOS linker and assembler.
- Third-party library support.
- Automatic generation of .COM files.
- Supports DOS pathnames, wild cards, and Input/Output redirection.
- Compatible with Lattice C version 2.x.
- Interrupt handling in C.
- Debugger support.
- ROMable code support/start-up source.

MAKE Maintenance Utility

- Macro definition support.
- MS-DOS internal commands.
- Inference rule support.
- TOUCH date manager.

Tools in Source Code

- cat—UNIX style "type"
- diff—Text file differences
- fgrep—Fast text search
- pr—Page printer
- pwd—Print working directory
- wc—Word count



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LETTERS

Software Gap

Dear *DDJ*,

After reading Nick Turner's Running Light column in the August issue concerning the perceived "software gap," I felt as though I had to tell you how I see it.

I hold a Bachelor of Science degree in computer science from the University of Maryland. I learned all about the "right" way to design and code programs, including everything you say programmers don't care about anymore. From my own experience, I find this to have been a waste of time and tuition.

The biggest problem I have had in my "career" has been convincing some of the "data processing managers" how a program should be constructed. Every time I try to write some form of documentation, I am told "not to waste time on such useless paperwork." I wish I could say this only happened at one or two companies, but I have been employed at four different companies over the past five years, and every one of them has been the same. I am beginning to think the only way I'll ever get to be what you call a "professional" programmer is to start my own software company.

At times I wonder if the problem with the management structure stems from the fact that most of the people promoted have business backgrounds. Not one of my bosses has ever had anything other than a business degree, and not one knows the first thing about a programming project. My current boss only understands straight-line coding and sequential list processing (that is, no doubly linked lists, no sparse matrices, no queues, and so on)—nice way to run a systems software development group that still uses a one-way line editor.

All I want is the chance to use what I learned in school and to be able to do a programming project correctly. It would be such a treat.

Name withheld by request

Dear *DDJ*,

I am writing in response to Nick Turner's August Running Light about sloppy programmers. I am a programmer/engineer, and I see a lot of sloppy programming. In fact, I do some sloppy programming myself. I think I might have a clue as to what is going on.

Turner mentions the programmers who can "write entire operating system kernels . . . in one pass, in assembly code, that run perfectly the first time . . . ." Well, I think they are the exception to the rule. I do not, however, doubt the premise that we can all do it, it just takes the rest of us a little more time and concentration.

So why don't we take the time, concentrate, and code better? I propose that the reason why we don't is the reward system that most of us work within. My manager seems to be less concerned that a project works the first time than he does that it is done. He wants to "see something." Granted, I work for a defense contractor and my manager wants to record milestones, not finish projects. But I think this attitude is more prevalent than most of us think.

Why, then, does this attitude and reward system not affect the hot performers? I think it is because they, at some level, do not respond to the same reward system as the majority. Every organization has at least one programmer who walks to the beat of a different drummer. This is not to say that all individuals who fit this description are great programmers, but most of the great programmers I know (or know of) are of this type. On the other hand, this tends to make them more difficult to manage, partially because they do not respond to the reward system that reflects the views of management.

So what can be done? Well, we probably won't change the managers or their ideas of how things should be done. From my own experience, I find that if they want to see something I have two choices. First, I can slop it together and debug it later (when I have less time). Second, I can "stub" it off, perhaps only coding the user interface or some visual part of the program. This lets the manager see something, but the code he sees is good code. Later, I go back and, instead of debugging, I write (for the first time) the code that I stubbed off in the first place. This seems like the way to go, but it is sometimes difficult to determine when to stop coding and start stubbing.

So I haven't really offered a solution. Just some ideas as to what I think the probable cause is and what I conceive I should be doing to change the

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(continued from page 10)

situation. I will be watching with interest to see what other readers have to say about this problem.
Name withheld by request

Avoid Woe when Upgrading MS-DOS

Dear *DDJ*,
Allen Holub's "A Tale of Woe" (C Chest, September 1986) sparked some vivid memories of upgrading from MS-DOS 2.11 to MS-DOS 3.10. MS-DOS 2.11 and earlier would search for an available file from the beginning of the FAT each time. MS-DOS 3.10 is more efficient because it allocates from wherever it left off. This caused me much grief in trying to change the attributes and delete and replace the two system files Allen mentioned, IBMBIO.COM and IBMDOS.COM for the PC and IO.SYS and MSDOS.SYS for generic MS-DOS. These two files must reside in the first clusters of the disk. The first data cluster is cluster 2. Additionally, they must be contiguous. You can delete and replace these two files by following a few simple rules. The total number of clusters must be no more than the original unless there are some unallocated clusters just beyond these two files. Under MS-DOS 3.10, you can unhide and delete these files and then reboot from a floppy. This will restore the FAT pointer to start searching at the beginning of the disk to modify. You may then copy the system files, which will now be the first n clusters, and they will be contiguous. Now the disk will be bootable. It helps to be able to track through the FAT and directories if there is a problem or if more space is needed. So there may be no need to reformat.

Max G. Heffler
Landmark Graphics Corp.
1011 Hwy. 6 S, #120
Houston, TX 77077

OS-9 Continued

Dear *DDJ*,
I was dismayed to see the thrashing Heitzso gave to the OS-9 operating system in his October letter. I disagree with both his specific examples and his general conclusions (please pardon the assumption of gender).

To start with, OS-9 cannot compete with Unix on disk speed; Unix keeps part of its file structure in memory whereas OS-9 always keeps its sector allocation bit map on the disk up to date. There is a clear speed advantage to accessing information in memory rather than on disk, but you pay a price in vulnerability. In this case, Microware chose to make the file structure robust and corruptionproof.

Heitzso illustrates the "real problems" he has had with OS-9 by describing his difficulty in using the *tsleep( )* function. After reading his letter I wrote a simple C program to test the *tsleep( )* function, and I was unable to make it malfunction for any number of ticks I specified, over a range of 1 to several thousand. In every case the timing was +/− one tick, just as specified.

The *tsleep( )* function accepts a single parameter indicating the number of ticks to sleep. Most OS-9 systems use a tick granularity of 1/100 second, which also happened to be the length of time Heitzso wished the task to sleep. I suspect that he requested that the task sleep for one tick; however, the documentation clearly states that a tick parameter of 1 causes the calling task to give up its present time slice. At the expiration of the time slice, the task will be put back on the active process queue, where it will compete for CPU time with other processes that are ready to run. If the calling task gives up its time slice near the end of a quantum and there are no other executable processes, it is quite possible that *tsleep( )* will return after an interval as short as 1/3,000 second.

Heitzso also describes how the OS-9 Format utility has a bug that prevents the user from specifying a cluster size greater than one sector. In reality, the documentation for the Format utility mentions that at present only a cluster size of one is supported!

I have yet to uncover a bug in the operating system. Microware's latest product discrepancy report lists a single bug in the operating system components, and it is triggered by an obscure condition in a little-used system call.

I disagree with Heitzso's conclusion that Microware's customer support is poor. I have found Microware to be quite reasonable in the dealings I have had with it. Microware provides bug lists and work-arounds to those who request them, and it offers a special telephone hot line for professional software developers. One of my gripes is that the hot line is too expensive, but I have heard that this may change. I hope so.

During a time when many experts in the computing field were touting the use of high-level languages as the best way to create an operating system, Microware quietly crafted an elegant, modular, and extensible gem in assembly language. I look forward to seeing OS-9 dominate the 68000 market as more people recognize its merits.

Kurt Liebezeit
Ordinate Systems
505 W. Springfield
Champaign, IL 61802

We didn't do our homework when we published Heitzso's letter. This issue contains a look at the OS-9 operating system by Brian Capouch—eds.

Correction

Dear *DDJ*,
The Microsoft-supplied correction to Version 4 of the Microsoft Macro Assembler that Ray Duncan gives on page 96 of the September 1986 issue of *DDJ* is incorrect. The "correction" as published causes MASM to go off into never-never land. The error in the listing on page 96 is a typographical one. The byte entered into address *xxxx:72D4* should be *E9* instead of *39*. This error appears in the string of 34 bytes that are entered starting at *xxxx:72B8*.

Robert C. F. Bartels
P.O. Box 2240
Ann Arbor, MI 48106

DDJ

PC MAGAZINE EDITOR'S CHOICE

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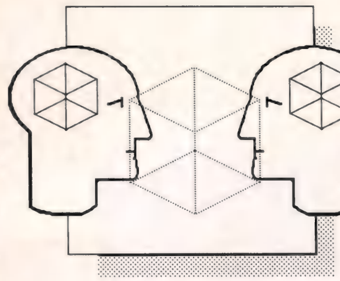

Logic and PROLOG

The touted virtue of PROLOG is that it provides a basis for programming in logic—hence its name. This suggests that logically correct descriptions or axiomatizations of a body of knowledge can be transcribed into PROLOG and that the appropriate deductions could then be drawn by PROLOG's inference engine. The idea of systematization of knowledge by way of postulates embedded in a deductive system has proven to be a powerful one since the time of Euclid. With the development of predicate logic by Frege and Russell, the idea received new impetus in this century. Many areas of mathematical and scientific investigation have axiomatic foundations—set theory being a prime example. The expansion and codification of knowledge by the deductive-axiomatic method, as the central methodology of knowledge, has its critics. But what has delayed its use outside theory construction itself is that, for practical real-time applications, hand-deduction from a knowledge base is too

by Dick Butrick

slow. What PROLOG promises is speed of deduction. You could simply query a knowledge base (axioms, postulates), and PROLOG would make deductions with computational speed—giving tremendous impetus to the deductive-axiomatic method as the central methodology of knowledge by removing the practical barrier to its use.

Unfortunately, the match between formal logic and PROLOG is tenuous at best. In fact, from a strictly logical point of view, PROLOG is inconsistent. Because any inconsistent deductive system is complete (if you can derive a contradiction, you can derive anything), PROLOG is theoretically complete. In implementation, however, PROLOG is not just inconsistent, it is incomplete. Time considerations and stack space are not considerations in pure logic, but these realities render PROLOG radically incomplete.

Of course, there are PROLOGs and PROLOGs. Specific reference here is to PLS PROLOG. However, the points raised apply just as well to Borland PROLOG and indeed to any nonpure, expanded, DEC-20-type PROLOG (Quintus PROLOG, CPROLOG, Poplog, and so on).

Typically, in testing out PROLOG as a deductive-axiomatic shell, a logician might enter postulates for the transitivity of *R*:

```
(x) (y) (z) (Rxy & Ryz --> Rxz)
```

In the Simple syntax of PLS, this becomes:

```
R(x z) if R(x y) and R(y z)
```

Given the *R*-facts *R(a b)* and *R(b c)*, it seems reasonable to query the system with *is(R(a c))*? PROLOG promptly responds with "no more space." Stack overflow has occurred.

This is not apt to impress the logician, or for that matter the layman, with the deductive power of PROLOG. At this point the dismayed logician might enter the PROLOG equivalent of *{p <--> q, p}* and query the system for *q*. The PROLOG equivalent is:

```
p if q
q if p
p
```

And the query is *is(q)*. "No more space" is again the reply.

At this point the logician might wonder if the inference engine is out of gas. In fact the system is in a goal-reduction loop. It reasons thus: To get *q*, first get *p*; to get *p*, first get *q*; to get *q*, first get *p*; and so forth. It never gets beyond the first two rules. In fact, *{p if p, p}* along with the query for *p* will put the system into an infinite loop.

This might seem a simple problem to solve, which of course it is for specific cases. In general, however, it can be shown to be unsolvable. A loop-detection procedure for a goal-reduction theorem prover is equivalent to the halting problem shown by Alan Turing in the 30s to be unsolvable. Essentially, a loop-detection monitor requires more logic than the goal reduction it monitors.

To make matters worse, the "no space left" response can be triggered without setting up a goal-reduction loop: *{H(x y) if H(x x), H(a a), H(b b)}* along with the query *is(H(a b))* causes stack overflow. In Borland PROLOG, *{H(x y if H(y x), H(a b)}* along with the query for *H(b a)* does the trick. If you cannot enter the postulates declaring the commutativity of a relation, then you might question whether PROLOG belongs in the remedial logic class for absolute dummies.

Examples such as the foregoing are legion, but they merely demonstrate the radical incompleteness of PROLOG. What is even more insidious is PROLOG's inconsistency. The treacherous dimension to PROLOG is not so much what it can't do as what it can. Consider the following deduction, based on the deduction rule known to logicians as mirabile dictu:

```
p if not q
q                          / Hence not p
```

Querying this little postulate set with *is(not p)* yields the astounding answer "yes." Not only that, the system will make further deductions on the basis of this fallacious deduction. Adding the postulate *r if not p* and querying the system for *r* yields the answer "yes." Again, such examples are legion.

Borland refers to PROLOG's treatment of negation as "novel." The justification for this novel treatment of negation is, according to Borland, the hidden assumption of the law of the excluded middle automatically made by PROLOG. Thus for the one-place predicate *h*, PROLOG automatically assumes *h(x)* or *not h(x)*. The latter is

(continued on page 138)

Dick Butrick, Ohio University, Athens, OH 45701. Dick is a professor in the Computer Science Department.

680xx Computers: Where Are They Going?

by Nick Turner

The 68000 led to the first powerful sixer machine.

Since the beginning of the microprocessor industry, two groups of programmers have emerged—a result of the divergence between those who liked the 8080 and those who liked the 6502. The 8080 had dedicated I/O instructions that used a separate address space, and it had several fairly specialized internal registers. Its instruction set was designed to be powerful and specific. To learn it programmers had to memorize its specialized instructions and address modes. Conversely, the 6502's instructions were more general purpose but less powerful. The instructions were easier to learn, but it took more of them to accomplish the same tasks. Its I/O was memory-mapped, making input and output identical (from the processor's point of view) to normal memory addressing. Memory-mapped I/O also reduced the number of specialized instructions that had to be learned. The two camps began to diverge as early as 1974, and by the early 80s, those programmers who were most fervent acquired the nicknames "eighters" and "sixers."

When the Z80 was introduced, the eighters suddenly had a much more powerful tool. The sixers had the 6800, and then the 6809, but there weren't many viable machines that used those chips. Ardent sixers had to be content with their Apple IIs and Commodore Pets and 64s. Certainly, some really magnificent work came out on the Apple II during the early 80s, showing that the Volkswagen of personal computers was a lot more powerful than had been thought. Toward the end of this period, some manufacturers tried to get the best of both worlds—for example, the OSI Challenger III, a strange machine with a Z80, a 6502, and a 6800 all in the same box.

For several years, it seemed likely that the Intel line of CPU chips would eventually take over the market. Many devoted sixers shuddered when the IBM PC turned out to have an eighter chip as its heart.

It wasn't until the 68000 appeared that there was a really powerful sixer machine. What led to the development of the 68000? Motorola's engineers perceived the need for a much more general instruction set so that the chip design could be cleaner and easier to mask. They wanted a CPU that would be upward compatible with future, more powerful chips, without the need for expensive "modes" that hamper functionality and take up space on the chip. For the most part, they seem to have succeeded. Though the 68000 does have some disadvantages and departures from a truly general-purpose design (such as the inability to store data using PC-relative addressing), it's a far cry from the restrictive modes and specializations of the high-end eighter chips. Motorola took an enormous gamble in introducing what was projected to be a whole series of CPUs with a completely new instruction set. Low-level programs had to be rewritten for the 68000. There was (and still is) a lot of momentum in the Intel line of chips. Has Motorola's gamble paid off?

Today's 680xx Line

To me the most valuable feature of the 68000 line, aside from the philosophy behind it, is the enormous range of speed and power available. With few or no changes to your software, you can move up from the 68008, which is roughly comparable to a fast Z80 in power, all the way to

Nick Turner, 501 Galveston Dr., Redwood City, CA 94063. Nick is a DDJ editor.

a 20-MHz 68020, which easily outperforms a small VAX.

Further, the line includes a wide and constantly growing selection of support chips. Most of the support chips are currently made by Motorola, but a growing number are being designed by other companies expressly for the 68000 line (an indication of the health of the 68000 standard). The most important support chips are the 68851 MMU and the 68881 FPU, both of which are true coprocessors when used with the 68020 (or later) CPU.

Perhaps as a result of the ease of designing with the 68000, a new flock of 68000-based computers has appeared in the last three years. Table 1, page 18, shows a sampling of the range of power and speed in the line. Of course, there are the relatively low-price personal systems, most of which have graphics-oriented interfaces. But you also have high-end workstations, such as the Sun systems and the Apollo Domain network, and a host of other high-end systems, including some powerful image processing equipment. The VME bus, originally designed around the 68000 line, has rapidly become a worldwide standard for rugged, powerful, modular computer systems. It's supported by an international coalition of companies, the VME International Trade Association (VITA), and is one of the most carefully defined system specifications I've encountered.

Some of the most interesting systems are the most recent. For example, the Mustang-020, a 68020-based system, has been available since last spring. It's amazingly powerful for its price, and it shows great promise as a general-purpose industrial machine. One of its chief assets is its size—in a box no larger than an IBM PC, it provides more power than do many minicomputers. Another system to watch is the Quantum QL, which comes from Sinclair in England. According to some preliminary literature, the entire computer is contained within a box the size of an IBM PC keyboard, and it runs a multitasking operating system called QDOS.

Software Issues

Because of its generalized and relatively simple design, the 68000 works well with multitasking operating systems—for example, Unix runs well under the 68020. Another interesting operating system that has recently been increasing in popularity is OS-9. Originally designed for the 6809, OS-9 is fast, small, and most important, highly accessible. (See Brian Capouch's article on OS-9 on page 30.)

The 68000 line also lends itself well to graphics-oriented interfaces because of its efficient handling of large memory spaces and its ability to easily accommodate large memory-mapped I/O spaces. The Macintosh operating system, for example, has set a new user interface standard for personal computers. Although the Mac OS (especially in its original incarnation) contained some major flaws, particularly in the area of disk organization, it has been much imitated, and most of the flaws have been corrected with the release of Apple's Hierarchical File System. The Amiga and Atari ST both have similar "desktop" screens, icons, and mice.

In the area of languages, the most prominent has been C. Table 2, page 18, illustrates some typical execution times of programs compiled in C on 68000-based machines. The benchmarks in the table were chosen to illustrate a variety of operations roughly representative of actual programs. C is in some ways perfectly matched to the 68000 line—the regularity and generality of the instruction set makes a language such as C almost a natural. Because of its relatively low-level nature, C translates readily into well-defined groups of machine instructions.

The Future

The 68000 line is the most serious competition for the Intel line, and the machines that use 68000s are varied and colorful. But will the 68000 line continue to grow and diversify? Will the industry support new members by

(continued from page 17)

creating products that incorporate them? I think so, for several reasons.

First, Motorola seems to have latched firmly to the idea that object-code compatibility is a must in the 68000 line. So far, each of the new CPUs has been almost completely compatible with its predecessors. The only exceptions come when you're writing time-slicing OS code or you have to deal with interrupts. Typically, that sort of code is fairly easy to upgrade, and the actual applications (if they're written intelligently) seldom require any changes.

Second, you can expect continued growth and diversity in the 68000 line. Some preliminary information on the 68030 processor has just landed on my desk. It will have not only the instruction cache of the 68020 but also a data cache, a memory manager, and much more. The result will be a CPU that has the 68020's speed in tight loops (because of the instruction cache) and that also can at times execute completely on-chip for extended periods (because frequently accessed data will be in the cache). The rumored 68040 may use a 64- or 128-bit data bus for reads (although it will still use a 32-bit bus for writes). It may contain an even larger RAM cache as well, plus a more powerful memory manager. In the peripherals department, the 68882 will be a more powerful, pin-compatible version of the 68881 floating-point coprocessor that, because of internal multiprocessing, will significantly outstrip the performance of its predecessor.

Finally, there are rumors of many other support chips floating around, along with some really fun rumors about 68100 or 68200 CPU chips. For example, how about a chip containing four 68030 equivalents, all executing simultaneously from dual, dynamically allocated 16K instruction and data caches? Of course, that's nothing more than a nasty rumor. There's probably no truth to it whatsoever.

A Dream Machine?

Will future developments live up to the expectations of software developers? So far the 68000 line has done well in a market that might otherwise have been completely dominated by Intel. The 80386 is strong competition, but the 68030 sounds like a programmer's dream. Unless some company takes over the sixer marketplace within the next few years, it looks like the 68000 and the more powerful related chips will prevail as the premier sixer CPUs.

DDJ

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Type	Maker	Model	Base Prices	Memory Range (Mbytes)	CPU	Clock Speed (MHz)	OS	Open Design	Intro Date
Portable	Sinclair	QL	$266	.5	68008	8?	QDOS	No	1986
Macalikes	Atari	ST 520	$800	.5-1	68000	8	TOS	No	7/85
	Commodore	AMIGA 1000	$1,000–$3,000	.25–4	68000	7.16	AmigaDOS	Yes	10/85
	Apple	Macintosh Enhanced	$1,700	.25-4	68000	7.8	Mac OS	No	4/86
		Macintosh Plus	$2,200	1–4	68000	7.8	Mac OS	No	1/86
		"Jonathon"	?	2–?	68020?	16?	Mac OS? Unix?	Yes	3/87?
Workhorses	Data-Comp	Mustang-020	$4,000	2	68020	12–16	OS-9	No	3/86
	Various	VME bus	$4,000–$20,000	.5-16	(various)	8–20	(various)	Yes	—
Workstations	Apollo	Domain	$9,900–$70,000	2–16	68020	12–20	Unix	Yes	2/86
	Sun	Sun II	$19,900	1–4	68010	10	Unix 4.2	Yes	11/83
		Sun III	$19,900	4–16	68020	16.7	Unix 4.2	Yes	9/85

Table 1: *Comparison of representative 680xx systems*

Benchmarks:

System	Compiler	Looptst (500)	Pointer (1500)	Fibtest (18)	Sieve (140)
Amiga	Lattice	44.3	37.5	48.8	81.7
	Manx Aztec 16	29.4	33.3	35.1	64.3
	Manx Axtec 32	38.4	35.1	40.1	80.7
Atari ST	Aleyon	25.6	28.4	31.2	56.5
	Lattice	30.7	30.7	35.0	62.3
	Mark Williams	30.7	30.0	37.2	60.1
	Megamax	25.6	35.3	33.3	53.9
Macintosh	Lightspeed	37.4	42.3	45.4	78.9
IBM PC	Microsoft C	25.8	30.9	37.1	60.1

Table 2: *Representative C compiler benchmarks (in seconds)*

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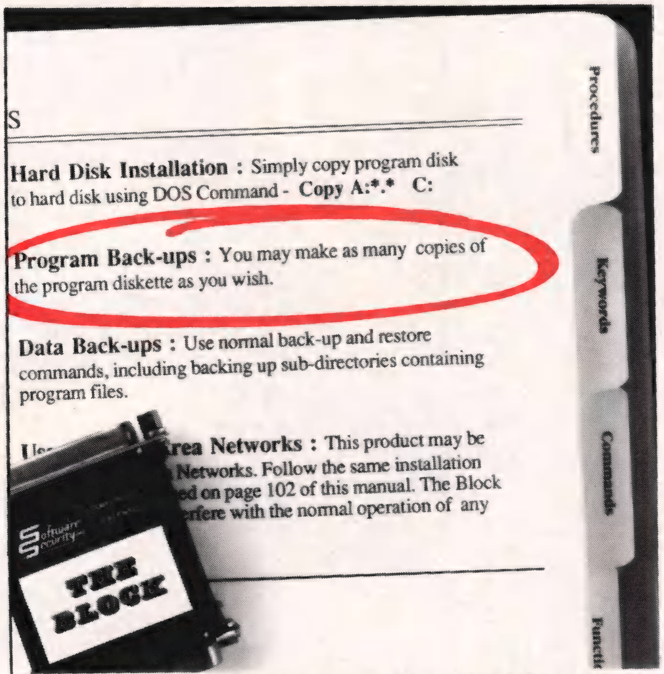
"How to protect your software by letting people copy it."

By Dick Erett, President of Software Security



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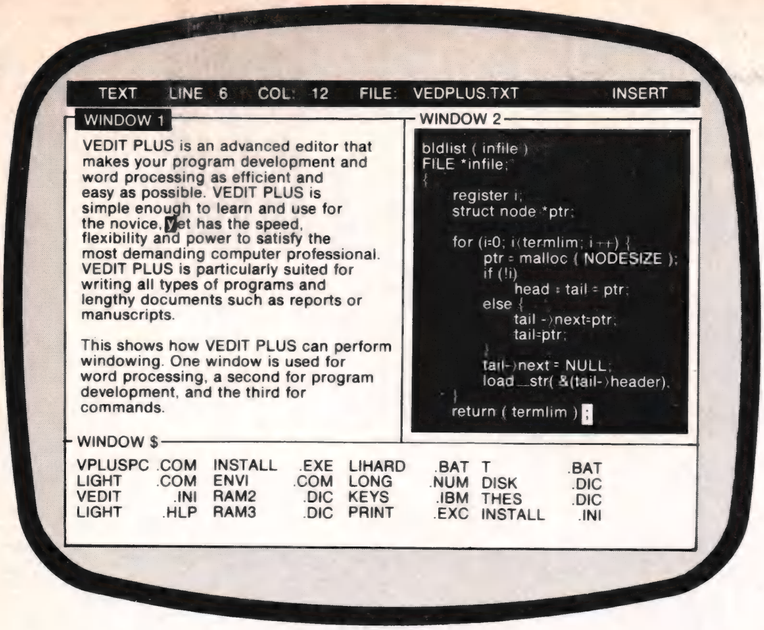

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A Mini Forth for the 68000

by G. Yates Fletcher

The inside approach to Forth makes the language much more palatable.

My exposure to Forth has been limited to the proselytizing of a few Forth fanatics, articles in various publications, and a fairly careful reading of Leo Brodie's excellent book *Starting Forth* (Englewood Cliffs, N.J.: Prentice-Hall, 1981). One of the attractions of the language for me is its fundamental simplicity. The interpreter, threader, and kernel of basic supporting words are small enough that (at least in theory) a single programmer can create a working system with a moderate amount of effort. I often toyed with the notion of doing it myself just for the learning experience (read that fun), but I never got to the point of making a serious attempt until last fall when I was assigned to teach for the umpteenth time our sophomore-level course in computer organization and assembly language. I was casting about for some way to generate enthusiasm, which although not a prerequisite for teaching seems to make the process more enjoyable for all concerned. It struck me that building a Forth system might make good programming exercises for my students. Thus was FLINT born.

I thought, what the heck, I'll write a "no frills" Forth and give the students the executable code (so they can play with it and see how it's supposed to work) and the source code minus the modules they will be required to write. By the time I've taught them enough about assembly-language programming to do the job and enough about Forth that they understand what is required, the semester should be winding down. Amazingly enough, everything went pretty much according to plan (albeit with considerably more sweat than I anticipated). As you might have guessed by now, the instructor probably learned a lot more than the students, but that's one of the reasons why I took the job.

G. Yates Fletcher, Dept. of Computer Science, North Carolina State University, P.O. Box 8206, Raleigh, NC 27695-8206. Mr. Fletcher is an assistant professor of computer science.

The product of this labor is not a standard Forth. As the venture was educational/recreational and not commercial, I never bothered to find out what the standards were or even look at the code for a real Forth. Thus I have chosen the acronym FLINT, for Forth-like interpreter and threader, to describe the system. FLINT was basically reverse-engineered from Brodie's description of the language, so the implementation is probably a blend of novelty and naiveté. Nevertheless, I feel that it is more than a toy, as I have used it to write a turtle-graphics program for my terminal; a full-screen editor (for Forth screens, of course); and a version of a standard prime-number seive benchmark (*Byte*, January 1983) that runs in a little more than 20 seconds on an 8-MHz 68000, making it faster than any of the microcomputer Forths listed.

I can conceive several levels at which this program may be useful. For those not familiar with Forth, it might help to be an introduction. It is no substitute for a good book such as Brodie's, but it could make a worthwhile companion. Those approaching Forth from the outside as another language are often put off or puzzled by its many idiosyncracies. The inside approach to Forth as a program gives a complementary perspective that resolves many of these mysteries and makes the language much more palatable. For do-it-yourselfers this program is evidence that novices can indeed produce something workable. They can read enough of the description and documentation to get a good idea of what needs to be done and blast off on their own, referring to the code perhaps when stuck or merely to confirm that their own way of doing things is better. Forth programmers who don't have a version running on their own 68000 machine might be able to revise and polish it up enough so that it resembles some usable standard. Forth cognoscenti might be interested to know that FLINT produces what I have since learned is subroutine threaded code (which seems to be particularly appropriate for the 68000) as opposed to the more usual indirect threaded code.

Overall Structure

FLINT was written with several goals in mind: to provide students with an example of a well-structured, real world, assembly-language program; to illustrate the utility and power of the 68000 instruction set and addressing modes; and to test the theory that Forth is more naturally understood as a program rather than as a language.

I've made a fairly serious attempt to structure and comment the code properly. Because everything is in

there somewhere, much can be learned (at least in theory) by reading the program carefully. In fact, several of my students have intimated (very discreetly) that they found the code much less confusing than my explanations of it. The 68000 assembly code comprises a minimal kernel of less than 500 lines and is arranged as shown in Table 1, below.

FLINT requires some basic BIOS support from the host in the form of macros that users must tailor for their own machines and resident system software. My system is a Sage II (now Stride), which has two floppy drives, 512K RAM, and 64K PROM and runs on an 8-MHz 68000. The PROM contains all the necessary BIOS support as well as a monitor/debugger that furnished an excellent environment for developing and running FLINT. Macro definitions for my system are in Listing One, page 52.

Interpreter and Dictionary

The token is the basic unit processed by the interpreter. Tokens are not obtained directly from the terminal but are taken from an 80-character line buffer. After prompting the user, routine *LINE* (Listing Two, page 52) fills the line buffer from the terminal and terminates upon receiving a carriage return character. *TOKEN* takes its input from the buffer and recognizes the blank as a token delimiter. The carriage return embedded in the buffer (the one that terminated *LINE*) is seen as a legal token whose execution returns control to *LINE*. In support of its buffer-filling function, *LINE* recognizes and handles backspaces.

The interpreter is composed of several routines whose operation forms an instruction cycle fed by the user interactively. The instructions are small modules of code called words whose actions are normally directed at data (or pointers to the data) residing on a parameter stack. The words are identified by short alphanumeric strings (tokens) that are symbols or English words that usually describe or are related to the action they perform. The words are arranged in a linked list in which each node contains the identifying token, a link pointer, and the code defining the word's action. This linked list is called the dictionary.

A dictionary entry starts with the identifier, which is a 4-byte value. It consists of the length and the first three characters of the name of the word being identified. For example, if the word were *EXECUTE*, the identifier would contain a 7 and then the characters *EXE*.

The next field is the link pointer, which is a 2-byte field containing the address of the previous word's identifier. Thus a dictionary search always starts with the most recently defined word and works backward. For larger systems you might want to make the link pointer a 4-byte value or perhaps make it a relative value instead of an absolute address.

After the link pointer is the code field, which contains the machine code that runs when the word is executed.

The outer interpreter is a loop that waits for and accepts input tokens, searches the dictionary until a match is found, and extracts the address of the corresponding code. The address can be sent to the inner interpreter for direct execution. If a token is not in the dictionary, it is assumed to represent a number in the current base, and its value is extracted and placed on the stack. If this attempt fails, an error is assumed and the *WHAZZAT* token is invoked.

Words can be defined as well as executed. The interpreter has an alternate compile mode (the standard mode is execute mode). The interpreter's primary task remains that of extracting the code address of an input token. When in execute mode, a *JSR* to this address is executed as before. But when the interpreter is in compile mode, a *JSR* to the code address is written into the dictionary. Execution is deferred until the word being defined is invoked in execute mode. Any number encountered in compile mode is handled by generating code in the dictionary that will push the value onto the stack at execution time. These compiled numbers are called literals. Additional support is provided for a submode in which words can be defined directly in machine code.

How FLINT Works

For a concrete example of how FLINT works, let's look at the activity that occurs as the first word in the inner shell, *CONSTANT*, is defined. Envision using this word interactively as follows:

```
10 CONSTANT TEN
```

or

```
12 CONSTANT DOZEN
```

CONSTANT will thus be invoked to define words that are constants. If, for example, you invoke the word *TEN*, you will expect it to push the number *10* onto the stack; if you invoke *DOZEN*, you expect *12* to be pushed; and so on. Let's call *TEN* and *DOZEN* instances of *CONSTANT*. Thus when *CONSTANT* is invoked, it will take the value of the instance from the stack and the name of the instance from the input stream.

Now look at the definition of *CONSTANT* to see how this activity is to be directed. The defining string is

```
: CONSTANT TOKEN HEADER LITERAL
                    CODE 3AFC 4E75 ;
```

The outer interpreter, operating in execute mode, picks up the token ":", finds a match in the dictionary, and proceeds to execute it. Examining the code for ":", you see that a subroutine call (*JSR*) to *TOKEN* will be excuted. The action of *TOKEN*, of course, is to pull in the next token from the input stream, and in this case it will be the token *CONSTANT*. The next *JSR* is to *HEADER*, whose action is to produce a dictionary header for the newly cap-

Outer interpreter
Line-buffer input routines: *PROMPT LINE*
Words supporting execute mode: *TOKEN, SEARCH, NUMBER, EXECUTE, WHAZZAT*
Words supporting compile mode: *COMPILE, HEADER, IMMEDIATE, ":", CODE, ";", ",", LITERAL*
System variables: *BASE, CBLOCK, EDBUF, DICT*
Words supporting disk I/O: *LOAD, GO, SAVE, INTERACTIVE*
Words supporting terminal output: *TYPE, ".", ".S"*
Miscellaneous words: *"(", QUIT, LOGOFF*

Table 1: *Arrangement of 68000 assembly code in kernel*

tured token *CONSTANT*. The remaining activity initiated by the definition will produce its code field.

The last activity of ":" is to set the compile flag, *FCOLON*, and return to the outer interpreter. The interpreter pulls the next token, *TOKEN*, from the input stream and extracts its code address. Because the interpreter is now in compile mode, a *JSR* to *TOKEN* will be written in the dictionary—that is, into the code field of *CONSTANT*. This means that the first activity of *CONSTANT*, when it is itself executed (called execution-time behavior), will be (surprise, surprise) to pull in the name of the instance from the input stream. In like manner a *JSR* to *HEADER* will become the next part of the code for *CONSTANT*, so now the execution-time behavior of *CONSTANT* has been defined up to the point where a header for the instance has been created. It is now time to define the execution-time behavior of *CONSTANT* that will define the execution-time behavior of its instances. Thus you must direct *CONSTANT* to take the value of its instance from the stack and write code in the dictionary that upon execution will place this value on the stack. This is an exact description of what *LITERAL* does, so its inclusion in the definition solves the problem neatly.

The activity *CONSTANT* must perform that has not yet been coded is to close the definition of its instance. At this point in the definition process, the outer interpreter, in compile mode, picks up the token *CODE*. A careful examination of the header for *CODE* shows that its listed token length is 132, which is 128 more than it should be. This is no accident. It is in fact the manner in which words are tagged as immediate, meaning that they are to be executed even when the interpreter is in compile mode. The necessity for such words should be obvious because otherwise, for instance, there would be no good way to terminate a definition. (When *TOKEN* picks up an immediate word, it sets the immediate flag, *FIMMED*, to let the interpreter know that the word is to be executed.) *CODE* sets the system base to 16 (hex); sets the code flag, *FCODE*; and returns to the interpreter.

When the tokens *3AFC* and *4E75* are picked up, they are not found in the dictionary. Thus each one is sent in turn to *NUMBER*, which extracts its proper hex value and places it on the stack from where the interpreter (now in code mode) copies them into the dictionary. The code *3AFC 4E75* translates as *MOVE.W #04E75H,(A5)+*. Thus the final activity in the run-time behavior of *CONSTANT* is to copy *04E75H* into the dictionary definition of the instance. Because *4E75* is the code for *RTS*, this activity will effectively close the definition of the instance. All that remains is to close the definition of *CONSTANT*. This is the job of ";", which resets the system base to 10, clears the compile and code flags, and writes an *RTS* into the dictionary.

Well, there you have it: just a simple little definition. Readers new to Forth (if there are any who have made it this far) probably feel that the claims for its simplicity are highly exaggerated, and even those with some familiarity may find themselves a bit glazed over. The bad news is that the operation of the FLINT compiler is often a fairly complicated activity. The good news is that it seldom gets any more complicated than the example given here. Complexity is after all a relative thing. Would anyone care to write a step-by-step explanation of the operation of a Pascal compiler on a segment of code that invokes most of its major machinery?

For beginners the definition of *CONSTANT* is as much a puzzle as it is an example. Understanding it requires clear thinking and a careful reading of the code involved. This is in fact one of the major reasons for discussing it. FLINT's interpreter/compiler is put to work at three levels. At one level the word *CONSTANT* is being compiled. To understand the activity at this level, however, you must see through to the level at which *CONSTANT* will be executed. This level itself must be understood in terms of the activity that will occur at the next level—that is, when a particular instance of the word is executed. The activity at all of these levels is mediated by the same interpreter. The code defining its basic structure occupies half a page, and many of the supporting words—for example, *EXECUTE, COMPILE, HEADER, ":", CODE, ";"*, and *LITERAL*—are only two or three instructions long. Finally, if you stand back from the example a little, you see that an entire data type has been created by a nine-word statement. I feel that anyone who understands the simplicity underlying this example has a firm grasp of FLINT and should have no real trouble mastering Forth.

The Inner Shell

Once the embryonic FLINT system is running, it is ready for a big meal of nourishing words that will give it more size and power. These inner shell words support:

- definition and manipulation of constants, variables, and arrays
- stack manipulation and stack arithmetic
- structured control for branching and looping

Listing Three, page 58, contains the inner shell words. Many of these words are defined directly in machine code (with the assembler mnemonics given as comments), so you might ask why they are not placed in the kernel and assembled as part of the basic system. My reasons for not doing so are primarily pedagogical. I wanted to maintain as much as possible the purity of the kernel to underscore its elegance and simplicity. In addition, the words, most of which are very short, seem to me to be more readable in Forth format than they are in assembly-language format. This representation, even allowing for comments, is much more compact because the work of building the headers is left to the system.

Structured control in Forth is directed by immediate words, placed in colon definitions to effect the compilation of appropriate conditional branching instructions. The flow of control is conditioned by values on the stack that act as flags. A zero value means false, and any nonzero value means true. As an example let's define the word *ODD*, which takes a number from the stack and prints an asterisk if it is odd:

```
: ODD 2 MOD IF 42 EMIT THEN ;
```

The action of *IF* when *ODD* is executed is to pop a value (assumed by *IF* to

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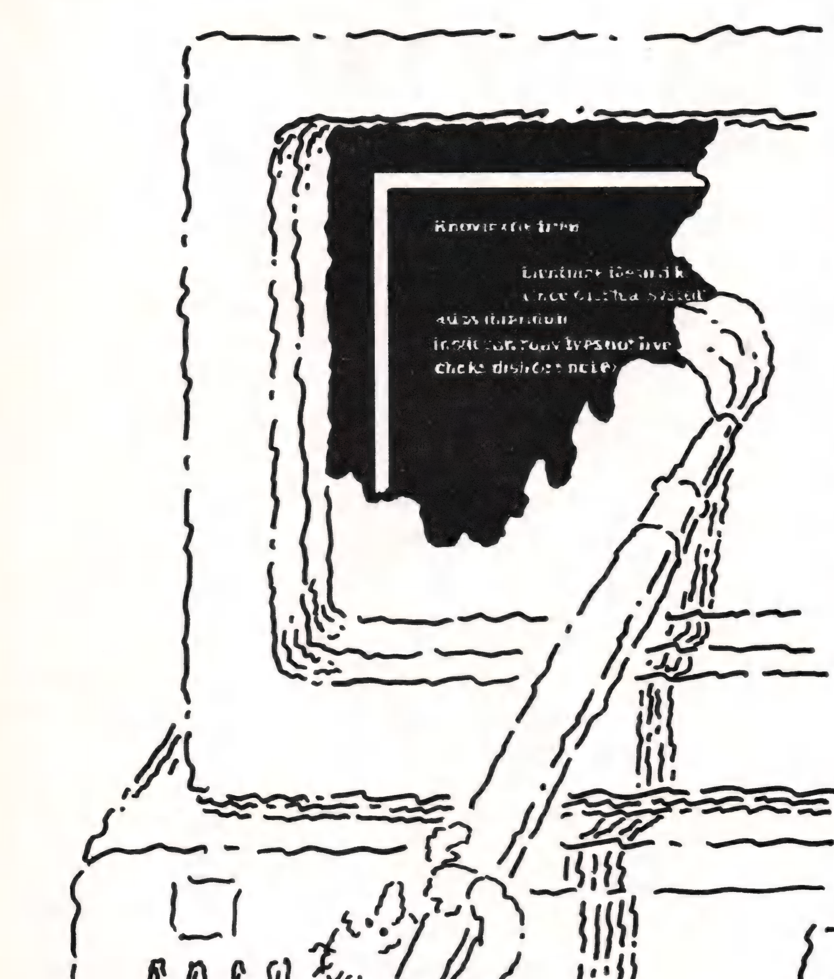

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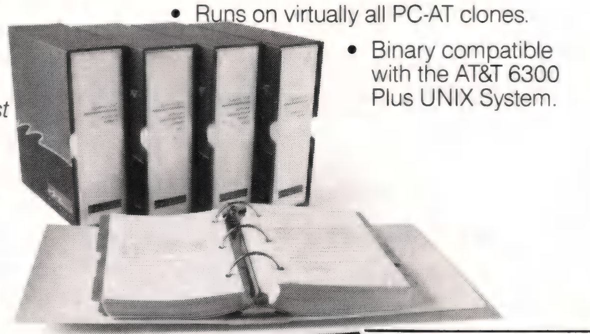

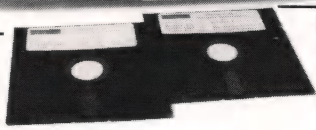

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68000 MINI FORTH

(continued from page 24)

be a flag) from the stack and test its value. If the value is false, execution continues at the word following *THEN* in the definition; otherwise, execution continues with the word following *IF*. In the above definition, the phrase *2 MOD* simply furnishes the proper flag for *IF* to "eat." The actions of *IF* and *THEN* when *ODD* is compiled (their compile-time behavior) must ensure that they have the desired effect when *ODD* is executed (execution-time behavior). Thus the definitions of *IF* and *THEN* will define their compile-time behavior, but they must be understood in terms of their execution-time behavior as well. An important point to remember here is that these words, as well as other control words, are not to be invoked directly; they act within definitions to achieve their effects.

Another control word, *ELSE*, can be used optionally with *IF* and *THEN*. If, for example, you wish to redefine the word *ODD* so that its action is to print the value of an odd number or else drop the number, you might try

```
: ODD DUP 2 MOD IF . ELSE \ THEN ;
```

The execution-time behavior of *ELSE* is, as you might suspect, to transfer control to the word following *THEN*. A subtle point here is that now *IF* must transfer control to the word following *ELSE* rather than to the one following *THEN* when *ELSE* is present.

FLINT provides two structured loop control mechanisms: *DO . . . UNTIL* and *DO . . . WHILE . . . LOOP*. The execution-time behavior of *UNTIL* is to eat a flag and pass control back to the word following *DO* if its value is true. Otherwise the loop completes when control passes to the word following *UNTIL*. *WHILE*, on the other hand, makes an exit to the word following *LOOP* if its value is false. *LOOP* always passes control to the word following *DO*. (Note that FLINT's usage of these words is different from standard Forth's; they seem to make a little more sense to me this way.)

Nowhere, I feel, is the elegance and power of Forth's programming paradigm more in evidence than in the definition of the lexicon of words supporting FLINT's structured control. The words *?>*, *BRA>*, *BEQ>*, and *BNE>* form the raw material for the tests and branches, and the words *MARK*, *SPLIT*, and *JOIN* provide the tools for assembling them. Each of the control words is then built economically by a single defining word or phrase, and yet when they are used any of the resulting control structures can be nested to arbitrary depth within any of the others!

Forth's elegance and power is evidenced by the lexicon of words supporting FLINT's structured control.

There remains the problem of entering these definitions interactively. In theory this is no worse than entering them into an assembly-language code file—except of course that all is lost when the system is turned off or (as is more likely) crashed by the novice user. My own approach to the problem was to try to find a way to save an image of the augmented system. As it turns out, all that is necessary for saving the state of the system is to preserve the contents of the internal dictionary pointer, register *A5*, which points to the next vacancy in the dictionary. (This happens to be the area used by *TOKEN* as temporary storage for the words that it extracts from the line buffer.) The word *LOGOFF* accomplishes this task by saving *A5* in the system variable *BUFPNT*, from which it is loaded each time *FLINT* runs. For this solution to work, you must have the means (via a monitor/debugger, for instance) to save and reload the augmented system in place of the original. Lacking such a tool, you should probably just bite the bullet and build the inner shell words into the source in the manner of the kernel words so that they will be assembled directly in the dictionary. This is tedious work, but it is not difficult if you understand the dictionary structure.

Ultimately, of course, it would be nice to dispense with these primitive methods and be able to create and edit disk-resident files of FLINT source text. In fact, the words *SAVE*, *LOAD*, and *GO* are included in the kernel system to support this very activity. The word *GO* directs the outer interpreter to take its tokens from a 1K reserved area known as the disk/edit buffer instead of from the line buffer. After the outer interpreter has exhausted the contents of this buffer, it will encounter the token *INTERACTIVE*, which has been placed in memory just beyond the buffer area. Execution of this word reinitiates the normal interactive input sequence and redirects the outer interpreter to take tokens from the line buffer. *LOAD* and *SAVE* allow the contents of this area to be read from or written to an absolute disk block called the current block, which is specified as the value of the system variable *CBLOCK*. A description of these words begs the obvious question of how usable text gets into the buffer (or on disk) in the first place.

My own solution was to use the expanded vocabulary of the inner shell to write a simple editor. Once this editor was built interactively, it could be used to place the text for the inner shell (as well as itself) in the edit buffer for eventual storage on disk via *SAVE*. These blocks of text are called screens. Careful examination of FLINT's initialization procedure will show that it loads and executes screen #80 (the initialized value of *CBLOCK*). This block and the succeeding ones are where the text for the inner shell and the editor have been placed. The word -> (defined on screen #80) directs the interpreter to increment *CBLOCK* and load and execute the next text screen. It allows an entire string of screens to be executed without interactive direction. By this device the inner shell and editor are effectively booted by FLINT whenever it is invoked. The final result is a fairly mature system that contains most of the basic features of a true Forth and enough legitimate tools to be quickly expanded further.

You can characterize the basic outline of FLINT's construction as a bootstrap procedure, which is really just

an accelerated and miniaturized version of the conventional process whereby low-level tools are used to build higher-level ones. The assembler is used to build an interactive interpreter/compiler (the FLINT kernel), which is used to incorporate a more sophisticated set of tools (the inner shell). These are then used to build an editor that allows the inner shell, the editor, and all future extensions to become permanent parts of the system.

The Aftermath

What, you might ask, did the teacher learn from all this? Well, for one thing, I relearned the value of ignorance. I sailed pretty far into the project on the momentum of my initial enthusiasm. It lasted, in fact, until everything was pretty much complete and working. Unfortunately, the job is not done when the program works. Cleaning up little messes, pruning, tuning, documenting, testing, and tracking down the subtle bugs—in short, the real work—was equally time-consuming but much less rewarding. Determination and good old-fashioned stubbornness had to finish what enthusiasm had begun. If I had fully realized in advance the amount of extra work involved, I would probably never have started. The moral here is that underestimating the magnitude of a task is often a necessary condition for attempting it. The work is still not finished, of course. It never is. The stack is in the wrong place, the realization of the *CODE* submode is imperfect, and so on, and so on. Any program is only an approximation of what it should be.

As far as Forth itself is concerned, there are several things to be said. I have acquired a terrific amount of respect for the ingenuity of Forth's inventor, Charles H. Moore. *Work of genius* is a term properly applied to such an engagingly simple yet immensely practical conception. I have not yet become, however, one of Forth's true believers. Programming is not my profession—it's actually more of a hobby—so I don't have enough real knowledge or experience to make any credible claims for its superiority or inferiority to other programming languages. I'll leave that issue to the people who make their money writing programs. My opinion is that Forth's programming paradigm of building the language to fit the problem allows (and indeed requires) a much more flexible and imaginative approach to programming problems than is called for with many more traditional languages.

The extra degree of freedom actually seems to require more self-discipline on the part of the programmer to use it wisely, but it makes problem solving more fun. I find that my programs tend to become compositions that I judge on aesthetic as well as functional grounds.

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(Listings begin on page 52.)

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The OS-9 Operating System

by Brian Capouch

The OS-9 operating system is a modular, multiprogramming, multitasking operating system (OS) that runs on a large variety of Motorola microprocessors. Designed to be conceptually similar to Unix, it provides programmers with a good environment for the same reasons that Unix does: it uses a hierarchical file structure, allows command-line invocation of concurrent processes, has a similar implementation of pipes and filters, and permits device-independent I/O. The differences are more important than the similarities, though.

Mean and Lean

OS-9 differs from Unix in several significant respects. It is, to turn a phrase, "meaner and leaner" than Unix. It occupies 12K of address space in its smallest 6809 incarnations and a little more than 48K in its full-blown 68020 form. It is more dynamically changeable than Unix, allowing users to add I/O devices and update system modules without rebooting a running system. It was also designed specifically to accommodate ROMed software easily and, for a variety of reasons, has proven suitable for real-time and process-control applications. These and other features have assured OS-9 a niche encompassing a wide variety of markets. This article gives an overview of the design of OS-9, particularly focusing on those aspects that make it special. I've included a pair of small application programs that are intended to give you the flavor of the OS-9

OS-9 is meaner and leaner than Unix.

programming environment

Origins

OS-9 originally had its genesis as part of a contract project between its designer, Microware Systems Corp., and Motorola, during the time that the hardware design of the 6809 processor was being finalized. The original concept of the project was to provide a modern, structured version of the BASIC programming language that would take advantage of the features of the 6809. The resultant language, called Basic09, incorporates several features that were at the forefront of language design; I'll review it briefly with examples later.

As the language development proceeded, Microware, with an eye toward the developing academic and commercial use of Unix, began developing an operating environment to complement Basic09's structure and modularity. Thus OS-9 was born. The language and the operating system appeared together in 1981, a few months after the 6809 came into production. As the design for the 68000 was begun shortly thereafter, Microware began a port of OS-9 for that processor.

As the 68000 and its successors have appeared in a multitude of applications, OS-9 has been ported into hundreds of designs. OS-9 currently appears on a wide range of machines, ranging from the 6809-based Tandy Color Computer to the GMX Micro-20, a 68020-based system that provides 2-megabytes of RAM, SASI and floppy-disk interfaces, serial and parallel I/O ports, and a 68881 math coprocessor on a card that mounts on a 5¼-inch disk drive. This machine has a performance that outstrips a variety of machines, including the VAX 11/780.

Named Modules

Structurally speaking, perhaps the most significant feature of OS-9 is its extreme level of modularity (see Figure 1, page 31). The underlying model of the OS-9 address space is a dynamic collection of named modules. When an executable module comes to life as a process, it is associated with a separate area of memory that is used to store its data. All code exists in what are known as memory modules, whether located in primary or secondary store. A memory module, generally, is a segment of code sandwiched between a header and a cyclic rendundancy checksum. The header contains information about the module that is used by the OS both during the time that the module is resident in memory and during transfers to and from secondary storage devices. The checksum is used to verify the integrity of the module during transfers to and from secondary store.

Modules that contain object code must consist of position-independent code and are shared automatically between various users of the system. This avoids having copies of the same object code occupying multiple sections of memory. In such cases, the OS assigns each user of the module to a different area of memory for data storage.

Brian Capouch, R. R. 2 Box 151, Monon, IN 47959-9229. Brian is a self-taught computer scientist who teaches at St. Joseph's College in Rensselaer, Ind.

The first bytes of each module are "sync bytes." These bytes, which consist of unused machine opcodes, are used at start-up to locate and load ROMed modules automatically. OS-9 permits ROMed code to be updated dynamically, simply by loading into memory a module with the same name as the ROMed module but with a higher revision number in its header. The mixture of modules that constitutes the "current environment" is more dynamic than in most other OSs, a feature that has opened up many application avenues.

Layered Hierarchy

Like Unix, OS-9 is organized as a layered hierarchy of functional modules. Each component is a memory module, as described earlier. At the lowest level of the hierarchy is the kernel, aided by small init and clock modules as well as several others. The OS-9 kernel handles all basic OS functions, including process scheduling and dispatch, memory management, and basic I/O processing. It determines from the init module the exact characteristics of its environment, which under OS-9 more than under Unix is likely to differ from one system to another. The clock

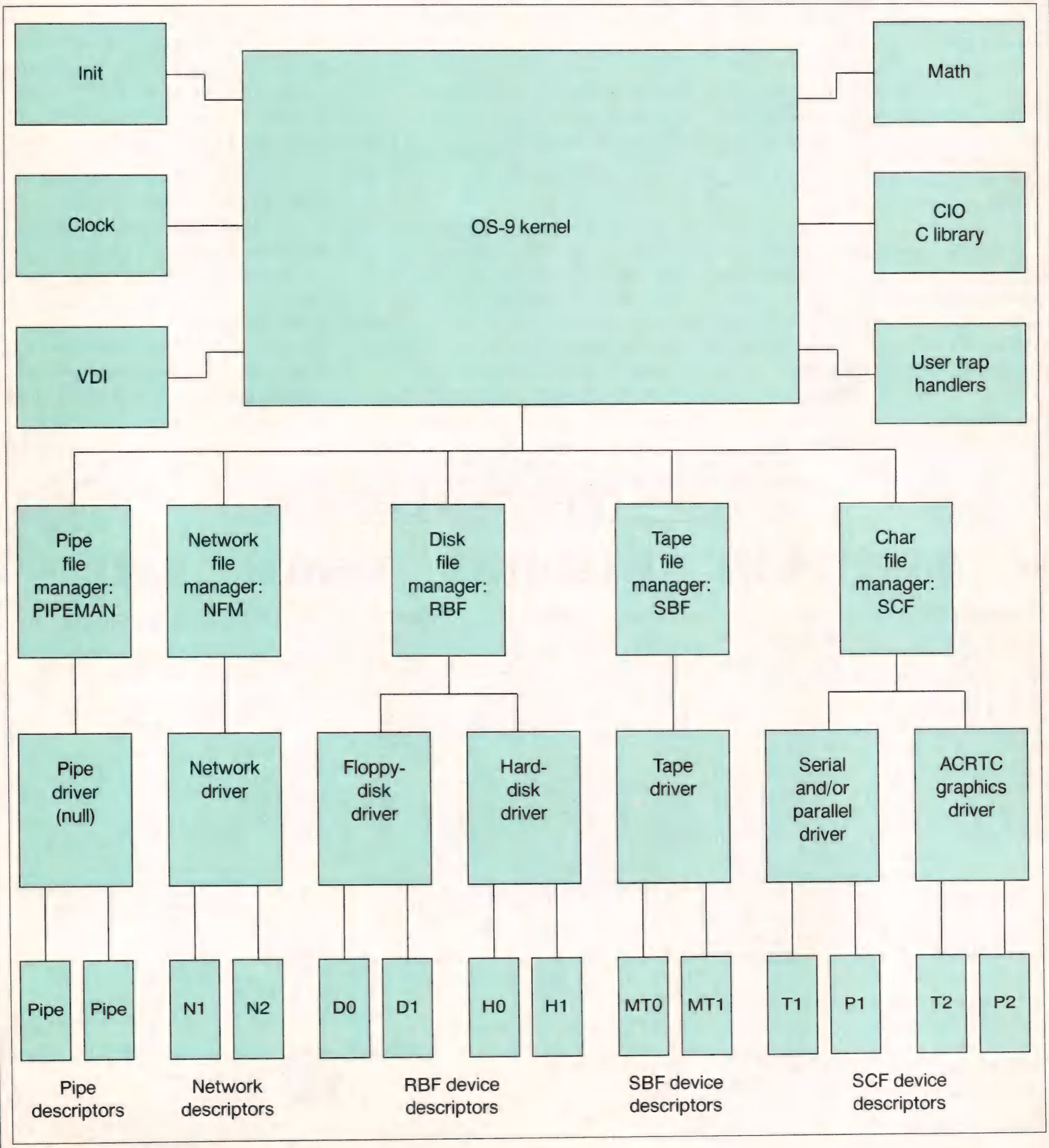

***Figure 1:** OS-9 module organization*

OS-9 OPERATING SYSTEM
(continued from page 31)

module interfaces to a tick generator for time-slice timing.

At the next layer outward from the basic system modules lie the file manager modules. Each of these is designed to interface the I/O data stream into and out of the processor and a particular class of similar devices. Because the conditioning is performed outside the kernel, all data appears to the CPU as equivalent byte streams. The module RBF interfaces to random-block-oriented devices, such as disks. SCF handles character streams that are bound for both parallel and serial I/O devices, and PIPEMAN coordinates data streams between concurrently running processes.

Each file manager conditions its data stream and passes it on to a device driver module. A device driver must exist for each different type of hardware to which the system is interfaced. The driver, such as a disk controller or intelligent interface processor, may control a large number of devices, and it is this level of the system that hides hardware dependencies from the lower levels of the OS.

At the highest level of abstraction are the device descriptor modules. The system needs one of these for each individual I/O device. They contain device-dependent parameters, such as port addresses, disk blocking factors, control characters, and so on.

The OS-9 unified I/O system is dynamically configurable, making it quite different from Unix. Devices can be added to and removed from running systems on the fly, and through changing device descriptors, different devices can be added to the same port and referenced interchangeably.

The 68xxx versions of OS-9 contain a complete math subroutines library that handles a wide variety of floating-point, extended-precision integer, and transcendental math functions. This package is called via the *Trap* instruction. Programs that use the library can be used without change on systems that implement hardware coprocessors by changing the trap handler associated with the call.

The User Interface

The OS-9 user communicates with the OS through a user interface called shell. Shell is similar to Unix shells, although it differs in enough respects to wreak havoc with the neuronal patterns of folks who try to time share between the two different OSs. Many of the utility commands go by what Microware thinks are saner names than their Unix equivalents, and utilities that depend on file structure and process specifics are of necessity organized differently.

One notable difference between the two shells is a set of OS-9 control characters that speed up line editing at the shell level. For instance, in other environments I have found myself constantly wishing for a "repeat line" control character (commonly assigned to Control-A) that provides the function "reenter the contents of the line input buffer up to the most recent carriage return entered." High-speed

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OS-9 OPERATING SYSTEM
(continued from page 32)

interaction with any processor leads to a large number of typographical mistakes, such as misspelling directory, file, or command names. The repeat-line character allows for quick reentry of the offending line, then backspacing to the point of error without having to retype the preceding characters. Although this may seem a picayune advantage to some, it can become addictive. Other control characters allow canceling the line, pausing the screen display, interrupting and canceling the currently running program, and so on. The characters that these functions map to are defined in the device descriptor and can be changed with the utility programs tmode and xmode. OS-9 also supports Unix-style type-ahead on serial input devices.

Development Tools

OS-9 programmers can choose from a variety of programming languages and functional processors. The OS-9 C compiler is Unix compatible down to the standard library level, and most of the system calls accessible from C have been assigned names that correspond to their Unix equivalents. One OS-9 hacker reported developing a reasonably complex program that included several low-level I/O calls using OS-9 C on his Radio Shack Color Computer. He then ported the program to a VAX 11/780, where it compiled and ran without a single change.

Besides C, there also exist compilers for Pascal, FORTRAN-77, COBOL, and at least four different versions of the BASIC language. These include Basic09, the language for which OS-9 was originally developed. Basic09 is an interesting and unusual language, and the example programs presented later demonstrate some of its features. Besides language processors, there is the usual plethora of functional processors, such as text editors, formatters, and so on. The standard OS-9 assembler is a relocatable macro assembler that allows management of complex assembly-language code in a variety of libraries that can be assembled separately.

More Differences

A few sundry points also underscore the differences between OS-9 and

```
Microware OS-9/68000 Resident Macro Assembler V1.6  86/08/18  14:02  Page     1
 syscall.a
OS-9 Assembly constants -
00001 *! Syscall Routine - From Microware Manual
00002                          use      <oskdefs.d>
00001                          opt      -l
00072
00003
00004  00000000                org      0
00005  00000000 Return         do.l     1
00006  00000004 Length1        do.l     1
00007  00000008 Param2         do.l     1
00008  0000000c Length2        do.l     1
00009
00010                          psect    SysCall,(Sbrtn<<8)!Objct,(ReEnt<<8)!1,0,0,SysCall
00011
00012 0000 0c80 SysCall        cmpi.l   #2,d0           check parameter count
00013 0006 6640                bne.s    ParamErr        branch if error
00014 0008 0caf                cmpi.l   #4,Length1(a7)  is first parameter integer?
00015 0010 6636                bne.s    ParamErr        branch if not
00016 0012 0caf                cmpi.l   #52,Length2(a7) 52 bytes of registers?
00017 001a 652c                blo.s    ParamErr        branch if not
00018 *!        Now put model on the stack
00019 001c 343c                move.w   #Modllen/2,d2   number of words for dbra
00020 0020 41fa                lea      Model+Modllen(pc),a0 get address of model
00021 0024 6002                bra.s    SysCO2          branch into loop
00022 0026 3f20 SysCO1         move.w   -(a0),-(a7)     move a word
00023 0028 51ca SysCO2         dbra     d2,SysCO1       continue if not done
00024 002c 2041                move.l   d1,a0           point to function code
00025 002e 3f68                move.w   2(a0),2(a7)     set function code
00026 *!           Get the registers
00027 0034 2a6f                movea.l  Param2+Modllen(a7),a5 get address of parameter
00028 0038 4cdd                movem.l  (a5)+,d0-d7/a0-a4 get register
00029 003c 4e97                jsr      (a7)            call function
00030 003e 48e5                movem.l  d0-d7/a0-a4,-(a5) copy register set
00031 0042 4fef                lea.l    Modllen(a7),a7 clear stack
00032 0046 4e75                rts
00033
00034 0048=323c ParamErr       move.w   #E$Param,d1     get error code
00035 004c=003c                ori      #Carry,ccr      set carry
00036 0050 4e75                rts
00037
00038 0052=4e40 Model          os9      F$Fork          model system call to put on stack
00039 0056 4e75                rts
00040
00041  00000006 Modllen        equ      *-Model
00042  00000058                ends
00043
Errors: 00000
Memory used: 19k
Elapsed time: 2 second(s)
```

Code Example 1: *Syscall, an OS-9 resident macro assembler*

Unix. First, the OS-9 kernel is written in assembly language instead of in C. Although this restricts the OS to a small set of machines, it results in faster, more compact code. OS-9 also uses a different scheduling algorithm—one that results in noticeably faster throughput than most Unix implementations. Because of its modular memory management and dynamic configurability, OS-9 lends itself better to low-level control applications and real-time processing. On the other hand, OS-9 does not swap programs into and out of primary store. Although this speeds up throughput considerably, it also means that once the total available RAM in a system is occupied, no more jobs can be run. OS-9 has no limit on the number of concurrently executing processes—one user reports spawning more than 600 of them on his 68020 system before running out of memory. OS-9 users also report that the substantially smaller memory requirements and faster speed of OS-9 suit it for many applications in which Unix is too large and slow.

Basic09

The example programs I have included with this article are designed to illustrate some interesting facets of OS-9. The Basic09 programming language is a highly modular implementation of BASIC that is not only compatible with most sophisticated versions of that language but also contains many structures that are seen in Pascal. It is an interpretive compiler that attempts to balance the better points of both translation processes. The language contains both an integral editor and debugger. Source code is compiled, a line at a time as it is entered, into an intermediate code. Syntax errors are reported to the user as each line is entered and can be immediately corrected using the editor. Programs consist of any number of named procedures in which a variety of data types can be declared and built up into named Pascal-record-like structures. Parameters can be passed between procedures by either value or reference, and *TRACE*, *PAUSE*, and *STATE* statements allow for interactive debugging.

The example programs illustrate some specific features: first, Basic09 programs can call and pass parameters to and from programs written in assembly language or compiled by other compilers. The program Syscall (Code Example 1, page 34) is a 68000 program that allows a Basic09 program to perform system calls from within a procedure simply by passing a 68000 register image and an OS function code. Because it is reasonably closely tied to the calling syntax for OS-9 assembly-language system calls and outside the scope of this article, I have chosen not to discuss it here and simply treat it as a black box. Procedure *ShowCall* (Code Example 2, below) illustrates how Syscall would be invoked in a Basic09 procedure. In this case, I simply use the Syscall routine as a substitute for the high-level Basic09 *OPEN* command. The system call, which opens the file for read, passes back a path number in the *d0* register, which is then assigned to the Basic09 variable *Path*.

The second example program, FormLetter (Code Example 3, page 36), illustrates a Basic09 procedure that adds a front end onto a standard text formatter. In order to personalize a form letter that I was preparing for a basketball team I coach, I wanted to incorporate names, addresses, and greetings from a demographic file into the body of a standard letter. My local implementation of the formatter does not permit reading from outboard files into the standard data stream. I chose to put together tools that I already had at hand rather than do a "Swiss army knife" modification to the text formatter. (At this point, please realize that I am well aware of the case for making a permanent addition to the formatter but would have lost an example for this article.)

The technique I chose was to create a pair of named pipes, one of which receives a stream of data headed for the formatter, the other one receiving its output. I then connected those pipes to file paths within the Basic09 procedure via calls to the OS-9 shell. It was possible thereby to integrate my demographics with the body of my letter, sending the merged data as standard input to the formatter. In this example I could then send the output of the formatter to a file, but I could have just as easily invoked yet another pipeline to have it processed directly by my system's print spooler. (Basic09 commands to do so are enclosed as comments within the pro-

```
PROCEDURE ShowCall
 0000
 0001      (* Procedure to demonstrate System Call from Basic09
 0036      (* Define complex data type to represent registers
 0069      TYPE registers=d0,d1,d2,d3,d4,d5,d6,d7,a0,a1,a2,a3:
                                                        INTEGER
 00A0
 00A1      (* Declare necessary variables
 00C0      DIM Path:INTEGER
 00C7      DIM Line:STRING[128]
 00D3      DIM IOPEN:INTEGER
 00DA      DIM Regs:registers
 00E3      DIM FileName:STRING[48]
 00EF
 00F0      (* Initialize Variables
 0108      (* IOPEN is OS-9 System Call I$OPEN: Open path to a file
 0141      IOPEN=$84
 0149      (* This is the file we'll be reading from
 0173      FileName="BOpen"
 017F
 0180      (* Set up register image for system call
 01A9      Regs.d0=1
 01B4      Regs.a0=ADDR(FileName)
 01C2      RUN Syscall(IOPEN,Regs)
 01D1
 01D2      (* Assign returned path number to Basic09 variable
 0205      Path=Regs.d0
 0210
 0211      (* Read and print file contents
 0231      WHILE NOT(EOF(#Path)) DO
 023C        READ #Path,Line
 0246        PRINT Line
 024B      ENDWHILE
 024F
 0250      (* Use Basic09 interface to close file
 0277      CLOSE #Path
 027D      END
```

Code Example 2: *Procedure to invoke Syscall*

OS-9 OPERATING SYSTEM

(continued from page 35)

gram.) These concepts can be extended in vastly more complex ways, all the while yielding the benefits of totally modular construction and interactive program development. The interactivity of Basic09 has left me consistently choosing it rather than C when portability is not a requisite, and I have found development to be much faster because of the interactive compilation, editing, and debugging.

Conclusions

I am tempted to call OS-9 the "poor man's Unix," even though I have to marvel at the power of its most sophisticated implementations, which are on par (or superior) to Unix running on a VAX in terms of speed and memory utilization. The concept of named, automatically located memory modules is an innovation that extends its capabilities into process control and real-time applications that are unsuitable for Unix, and its user interface and overall organization enable those familiar with Unix to adapt to its operation quickly. Its growing user base indicates that what was considered for many years an underground classic is now emerging from the shadows, and it should provide an interesting and productive environment for programmers of machines based on Motorola processors for years to come.

I would like to thank GMX Corp. for providing me with one of its Micro-20 systems for evaluating that implementation of OS-9.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063 or call (415) 366-3600 ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

DDJ


```
PROCEDURE FormLetter
 0001       (* Formletter: Add a front-end to K & P text formatter
 0039       (* Written by Brian Capouch, 7/86
 005C       (* Define complex type to hold demographic info
 008C       TYPE NameRec=Name,Add1,Add2,Greeting:STRING[80]
 00A8
 00A9       (* Declare variable storage
 00C5       DIM Record:NameRec
 00CE       DIM NameFile,BodyFile:STRING[48]
 00DE       DIM Includer:STRING[10]
 00EA       DIM NamPath,SplPipe,InPipe,OutPipe:INTEGER
 00FD       DIM Counter:INTEGER
 0104       DIM Line:STRING[256]
 0110       DIM Index:INTEGER
 0117
 0118       (* Trap out EOF coming down pipeline
 013D       ON ERROR GOTO 10
 0143
 0144       (* Initialize variables
 015C       NameFile="Demographics"
 016F       Includer=".us Body"
 017E
 017F       (* Set up files
 0190       OPEN #NamPath,NameFile:READ
 019C       GET #NamPath,Counter
 01A6
 01A7       (* Set up output path to file
 01C4       CREATE #SplPipe,"LettersOut":WRITE
 01D9
 01DA       (* Send each set to formatter, with preface and suffix
 021E       FOR Index=1 TO Counter
 0230         (* Set up pipes to text formatter
 0252         (* This procedure "owns" this named pipe
 027B         CREATE #InPipe,"/pipe/in":WRITE
 028E         (* Now couple this pipe to text formatter
 02B8         SHELL "runb tformat </pipe/in >/pipe/out&"
 02DF         (* Open path to output pipe from formatter
 030A         OPEN #OutPipe,"/pipe/out":READ
 031F         (* Next two lines commented out
 033E         (* They would send output to spooler instead of a file
 0374         (* SHELL "spl -nj </pipe/SplIn"
 0394         (* OPEN #SplPipe,"/pipe/SplIn":write
 03BA         (* Now process data
 03CE         GET #NamPath,Record
 03D9         RUN PrintHeading(InPipe,"7/24/86")
 03ED         WRITE #InPipe,Record.Name
 03FA         WRITE #InPipe,Record.Add1
 0407         WRITE #InPipe,Record.Add2
 0414         WRITE #InPipe
 041A         WRITE #InPipe,Record.Greeting
 0427         WRITE #InPipe
 042D
 042E         (* Send some commands to the formatter
 0454         WRITE #InPipe,".fi"
 0460         WRITE #InPipe,Includer
 046A         WRITE #InPipe,".bp"
 0476         CLOSE #InPipe
 047C
 047D         (* Get output from formatter, send to spooler
 04AB         WHILE NOT(EOF(#OutPipe)) DO
 04B6           READ #OutPipe,Line
 04C0           WRITE #SplPipe,Line
 04CA         ENDWHILE
 04CE
 04CF 10      (* We return here after each EOF trap
 04F8         CLOSE #OutPipe
 04FE       NEXT Index
 0509       CLOSE #NamPath
 050F       CLOSE #SplPipe
 0515       END
 0517
 0518 100   (* EOF on pipe generates OS-9 Error #211
 0544       ErrNo=ERR
 054B       IF ErrNo<>211 THEN
 0558         PRINT Beep;
 055E         PRINT "System Error--->No. "+STR$(ErrNo)
 057B         END
 057D       ELSE
 0581         GOTO 10
 0585       ENDIF
 0587       END
```

Code Example 3: *Procedure to add front end to text formatter*

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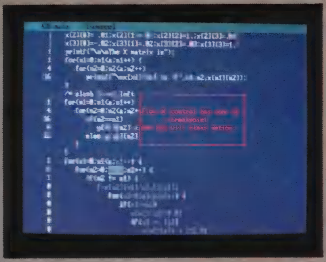
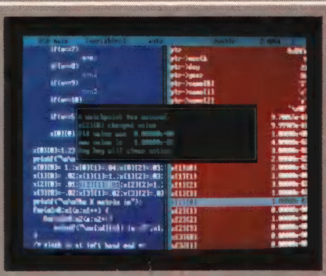
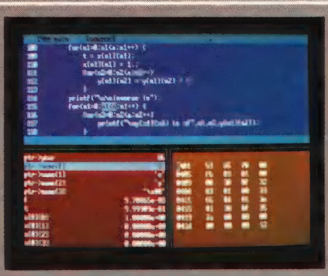


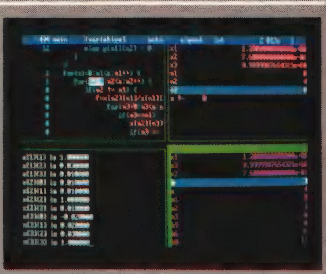
Source window with profile count showing number of times each statement has executed. Pop up message indicates break point has been hit.



Source and variables windows shown side by side. Pop up message indicates that a watch point condition has been satisfied.



Source, variables, and memory window. Memory window lets you view any area of memory using any data type.



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System Requirements
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Macintosh Buttons and Amiga Gadgets

by Jan L. Harrington

When you put aside emotional reactions to the Macintosh and Amiga computers to take a more objective look at the two machines, it appears that, at least in concept, they are more alike than different. In addition to similarities in user interface standard, both use the 68000 microprocessor. Both have operating systems that are partially in ROM and partially on disk. Programmers who wish to adhere to the standard user interface make use of a set of system routines to create and manage windows, menus, graphics, and text.

The functions that the Macintosh and Amiga system routines provide are not equivalent, however. The Macintosh, for example, provides text handling routines not found on the Amiga. By the same token, the Amiga libraries contain animation routines not found on the Macintosh. The disparity between the functions provided by system routines presents challenges for programmers, especially if they are attempting to adapt software from one machine to the other.

This article explores the details of the standard Macintosh and Amiga user interfaces, examines the system routines programmers use to create those interfaces, and discusses those system routines through a pair of sample 68000 assembly-language programs that support a portion of the standard user interfaces.

Jan L. Harrington, 4002 Stearns Hill Rd., Waltham, MA 02154. Jan is an assistant professor in the Computer Science Department at Bentley College. She is the author of Macintosh Assembly Language: An Introduction.

The Mac's system routines support its user interface more completely.

User Interface Standards

The Macintosh standard user interface has caused many people to redefine what they mean when they say software is easy to use. You expect to be able to run a Macintosh program by double-clicking its icon on the Macintosh desktop. You expect to find at least Apple, File, and Edit menus present, and you expect those menus to behave in a consistent manner (they should "pull down" to expose the menu items, some of which may be associated with a keyboard equivalent). You expect to be able to use scroll bars to move throughout a document and to be able to simulate a click on an OK button by pressing the Return key. The Macintosh user interface standard is clearly defined in Chapter 2 of *Inside Macintosh*,[1] the extensive technical documentation for the machine.

The Amiga also supports a mouse-driven interface. Amiga applications that have icons can be run by double-clicking that icon from the Workbench window with the left mouse button. Amiga menus also pull down, the result of right mouse button action. Menu items can be associated with keyboard equivalents, and Amiga software has appeared with scroll bars.

The Amiga interface standard, however, is not as strictly defined as is the Macintosh standard. Suggestions for the interface do appear in the *Intuition*[2] manual, the part of the technical documentation that describes the routines supporting the windowing environment.

The window is central to both the Macintosh and Amiga. You can move windows about the screen (that is, within the same plane), move them relative to other windows on the screen (that is, from front to back), size them, and close them. All of these functions are initiated by mouse action on some portion of the window. Window movement within the plane is controlled by the drag region, that part of the window's title bar not taken up by the window title or other graphics. A click of the mouse button on a box at the far left of the title bar will close the window (the Macintosh calls it a "GoAway box," the Amiga a "CloseWindow gadget"). The Amiga window title bar also contains, at the far right, gadgets that move the window from front to back ("depth arrangement gadgets"); Macintosh windows move back one layer when another window is activated and brought to the front. In both machines, windows are sized with the overlapping boxes that appear in the lower-right corner of the window (the Macintosh calls it a "grow icon;" the Amiga calls it a "sizing gadget").

Both the Macintosh and Amiga collect information and give warnings using special windows. The Macintosh uses "dialog boxes" to collect information and "alerts" to give warnings. For example, a dialog box will appear to accept the name under which a file should be saved, and an alert box appears if you attempt to close a document window without

saving its contents. The Amiga uses "requesters" to collect information and "alerts" to let you know that something catastrophic has occurred. Requesters are analogous to dialog boxes, but whereas Macintosh alerts signal that a potential for harm occurs, Amiga alerts appear only after it's too late to recover. Amiga alerts are generally equivalent to Macintosh system alerts (generated by 68000 system errors). Usually you close requesters, dialog boxes, and Macintosh alerts by clicking on a small rectangle containing a message such as OK or Cancel. (The Amiga calls the small rectangles "gadgets"; the Macintosh calls them "buttons," which are a type of "control.")

Menus, too, are essential to both the Amiga and Macintosh user interfaces. Macintosh menu titles are visible at all times across the top of the screen in the "menu bar." The Amiga "menu strip," which also appears across the top of the screen, is visible only when you press the right mouse button.

Menus on both computers pull down; the menu choices appear in a box below the menu title as you drag the mouse pointer over them. Amiga menu items may also have submenus, which appear when the mouse pointer is dragged over the menu item. In either machine, menu items can be associated with keyboard equivalents—a single character that, when pressed in conjunction with a special modifier key (the command key on the Mac, the solid A key on the Amiga), simulates the selection of a menu item with the mouse.

Both computers maintain menu definitions as linked lists of data structures containing data needed to draw the menus. At any one time, the Macintosh supports only one menu list. You can make changes by inserting and removing menus from the list. The Amiga logically attaches menu lists to windows rather than to the screen, making it possible for many menu lists to be present in memory at any given time. Which menus appear when you depress the right mouse button therefore depends on which window is active at the time.

A Macintosh program that adheres to the standard user interface has at least three menus. The Apple menu appears at the far left of the menu bar; its title appears as an apple icon (an apple with a bite taken out of it). The Apple menu supports the Macintosh desk accessories. The second menu from the left is the File menu. The File menu opens, closes, saves, and prints files and exits from the program to the operating system. The third menu, the Edit menu, handles the text editing functions—Cut, Copy, Paste, Clear, and sometimes the Undo function as well.

The Amiga does not provide routines to implement its own standard interface recommendations.

Amiga programs that follow the interface suggestions made in the *Intuition* manual provide at least two menus in each menu strip. The leftmost menu is the Project menu, which is analogous to the Macintosh File menu—it manages opening, closing, saving, and printing of files as well as exiting from the program to the operating system. The second menu from the left is an Edit menu, which provides access to the same editing functions as the Mac's Edit menu.

Text editing standards are also an important part of both the Macintosh and Amiga user interfaces. Macintosh programs that support text entry of any kind, including even the entry of a single line into a dialog box, support cut, copy, and paste operations from a standard Edit menu. The editing functions are also present in programs that do no text editing because desk accessories use cut, copy, and paste even if an application does not. Amiga programs that require text entry (most notably word processors) support the same text editing functions as Macintosh programs do, but the absence of desk accessories means that Edit menus do not appear in programs that are not concerned with text.

Implementation

To explore the support the Macintosh and Amiga provide for their standard user interfaces, I wrote two programs in 68000 assembly language, one for each machine (see Listings One and Two, pages 64 and 69 for the Macintosh program and Listing Three, page 69, for the Amiga program). The programs are more or less equivalent in function. Each opens a window for text entry (the Amiga program also opens a custom screen) and creates menus (three for the Macintosh, two for the Amiga). Each supports the entry of text from the keyboard. The programs both terminate if you either select Quit from the appropriate menu or click the mouse pointer on the box that closes the window. Both also make extensive use of constants and data structure offsets from the include files supplied with the Macintosh 68000 Development System and the Amiga Macro Assembler, respectively.

The Macintosh system routines are invoked through the 68000's trap mechanism (all system calls are assembled to begin with *%1010*, which is then trapped by the microprocessor). The trap mechanism retrieves the actual location of the routine from a jump table, which is loaded from ROM to RAM at system start-up. Calls to system routines are performed with trap macros, all of which begin with an underbar (for example, *_GetRMenu*). The trap macros themselves are defined in the Macintosh's include files. Macintosh system routines are organized into "managers," which must be initialized before the routines are called. Lines 5–14 of Listing One initialize all the Macintosh managers.

Amiga system routines are contained in libraries. All libraries except the exec must be opened before they can be used. This includes the intuition library, which is opened at the top of Listing Three with a call to the system routine *OpenLibrary* (lines 44–51). Each library has a base address. Exec's base is fixed and assigned to the constant *_AbsExecBase*; all other library bases are returned by *OpenLibrary*. System routines are

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called as subroutines whose starting addresses are relative to the library base, which is placed in register *A6* before the call. Assuming that the correct address is in *A6*, calls to Amiga system routines are handled by the macro *callsys* (lines 4–6).

The functional differences between the two programs are the result of the system routines available on the two computers. The Macintosh program, for example, has a menu the Amiga program does not. The Apple menu is provided for the Macintosh's desk accessories. Implementation of the desk accessories is handled completely by a series of calls to system routines. The text in the Macintosh window will word wrap because the routines that manage the text editing environment automatically handle that function. The editing operations—cut, copy, and paste—have also been implemented because each is handled by a call to a single system routine.

The Amiga does not support desk accessories and so has no equivalent to the Macintosh's Apple menu. The Amiga also does not provide system routines for doing word wrap or the standard editing functions. Therefore, text entry in the Amiga window is exactly like using a typewriter. On the other hand, the Amiga window can be sized, moved about the screen, and moved back and forth in the plane. These functions are handled automatically by the Amiga's operating system; they do not need to be included in an application's code. Performing the same operations on the Macintosh requires including additional program code (calls to system routines).

The Amiga program is more than twice as long as the Macintosh program. There are two major reasons for this. First, the Macintosh can obtain parameters for creating data structures (for example, windows and menus) from a resource file. A resource file contains templates that describe the contents (for example, items to appear in a menu), location (for example, initial coordinates of a window), and characteristics (for example, menu items that should initially be disabled) of structures an application will use. The Macintosh program's resource file (Listing Two) contains templates for the three menus and one window. Second, although both the Macintosh and the Amiga maintain data about program objects in linked lists of data structures, Macintosh system routines perform most of the structure initialization and list management, whereas the Amiga leaves those functions to the programmer. The amount and type of programming required to achieve the same program function is therefore rather different on the two machines. You can see examples of these differences, especially in terms of creating menus and windows, when the two sample programs perform event trapping and do text I/O.

Creating Menus

The Macintosh can create a menu by calling the system routine *GetRMenu*. *GetRMenu* reads the template from the resource file, allocates space in RAM for the menu record, and loads the data into the appropriate locations in that menu record. Menu items are stored in a linked list. The routine requires one parameter (the resource file ID that identifies the menu) and space on the stack for a handle to the menu record. After the routine is called, an application pulls the handle from the top of the stack, where it has been placed by *GetRMenu*. Initializing a menu record therefore requires four lines of code. The template for the Macintosh program's File menu, for example, appears in lines 5–14 of Listing Two. The menu structures are actually initialized in lines 29–32 of Listing One.

Initializing a menu data structure for an Amiga program is considerably more complex. Assuming that the menu items are to be text rather than graphics, the text must first be loaded into intuition text structures. Each intuition text structure must be included in a menu item structure. The menu item structures are then assembled into a linked list whose head is incorporated into the menu data structure.

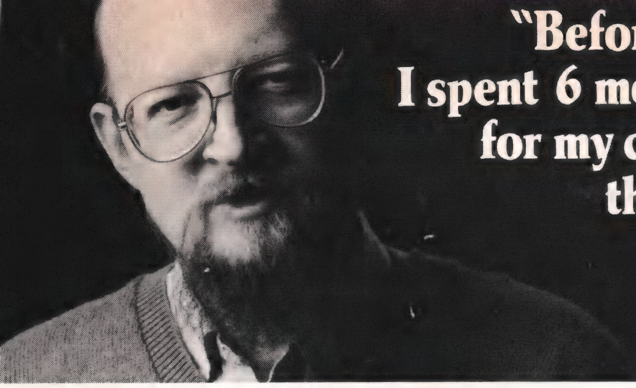
In the program in Listing Three, the intuition text structures are initialized in the subroutine *SetText* (lines 257–265), which is invoked by the macro *passtext* (lines 10–14). For each menu item, the text must be included in the program as a constant. The program must also allocate space for the intuition text structure (see lines 354–393 for the data structures associated with the Amiga program's menus). The intuition text structures for the Project menu, for example, are handled in lines 92–98.

Once the intuition text structures have been initialized, the menu items are initialized and chained into a linked list. The actual initialization is performed by the subroutine *SetItem* (lines 266–277), which is invoked by the macro *passitem* (lines 15–22). It is up to the programmer to allocate storage for each menu item data structure and to load the list pointers correctly. The Project menu's menu items are initialized and linked in lines 99–111.

The final step in the process is the initialization of the menu data structure. All the menus that will be present in a single menu strip are maintained in a linked list. Therefore, the initialization must include setting a pointer to the next menu in the list. The programmer must also determine coordinates for the physical position of the menu in the menu strip. The Amiga program sets up the Project menu in lines 112–123. After the Project menu has been completed, the entire process is repeated for the Edit menu.

The Macintosh requires the use of a separate system routine to insert menus into the linked list of menus that will appear in the menu bar at any given time. *InsertMenu* handles the insertion of a menu into the menu list. A programmer supplies either the handle of a menu after which this menu should be inserted or a parameter indicating that this menu should be last (that is, rightmost). Lines 33–35 of Listing One, for example, insert the File menu into the Macintosh's menu list.

Merely inserting a menu into the menu list does not, on either machine, display the menu. The Macintosh routine *DrawMenuBar* (see line 43 in Listing One) is equivalent in function to the Amiga routine *SetMenuStrip* (lines 149–152 in Listing Three). The Macintosh routine actually displays the menus currently in the menu list on the menu bar; the Amiga routine attaches the menu list to a window so



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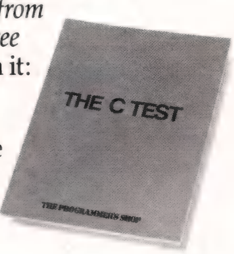

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that, when the window is active and the right mouse button is depressed, the menu strip appears.

There are both advantages and drawbacks to the Amiga's way of handling menus. The major drawback is the burden the Amiga places on the programmer. Establishing Amiga menus requires a great deal of work to initialize data structures and a great deal of care to ensure that pointers are stored properly. The Macintosh, on the other hand, isolates the programmer from dealing directly with the data structures and from list management. The trade-off is flexibility. Macintosh menu items are restricted to text (though a limited number of icons can appear with them), whereas Amiga menu items can be graphics (the intuition text structures can be replaced with graphics data structures). A Macintosh programmer has control only over the relative placement of a menu in the menu bar; an Amiga programmer can determine exactly where a menu should appear.

Creating Windows

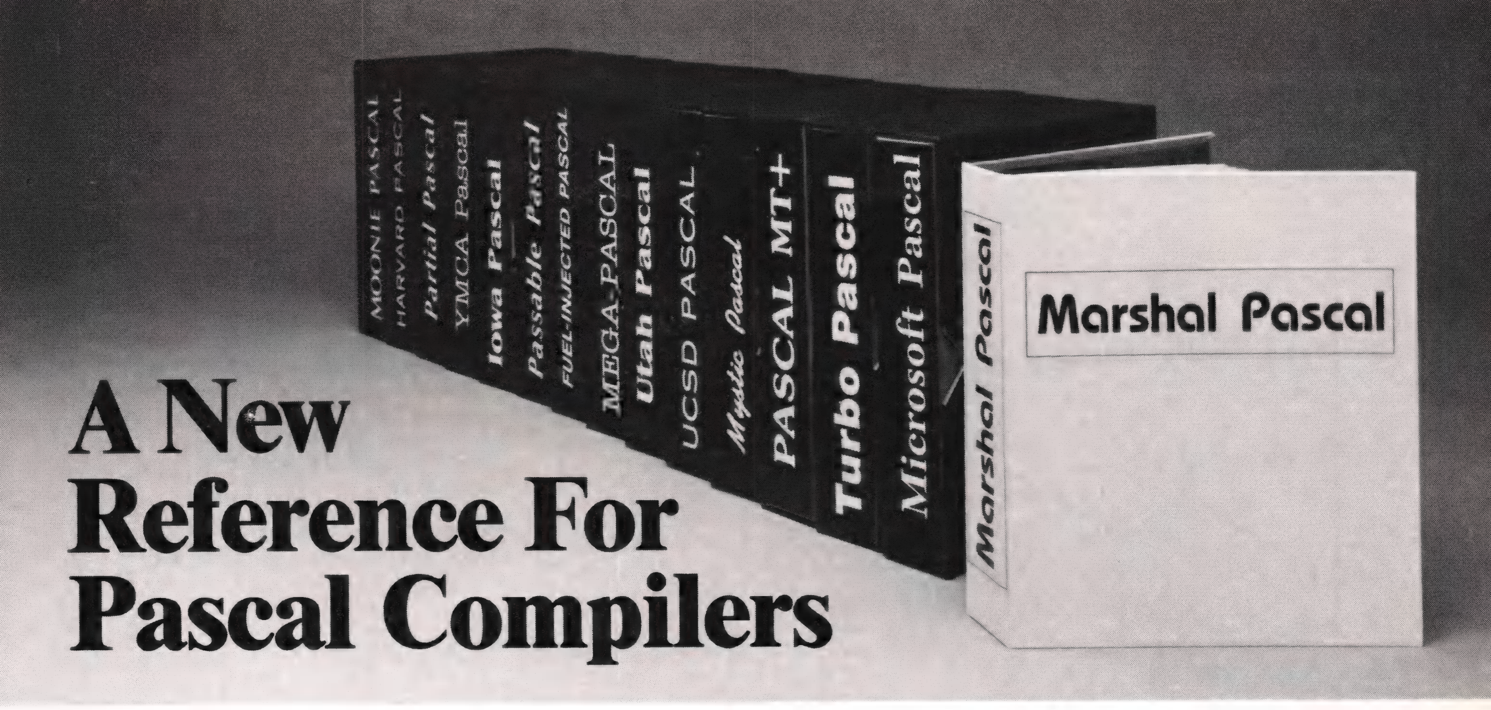
Macintosh windows can also be defined by templates in resource files (see lines 24–29 in Listing Two). An application can then create the window by pushing space for a window pointer on the stack, pushing three parameters, and calling *GetNewWindow* (see lines 44–49 in Listing One). The programmer must provide storage for the window record and for its pointer (lines 195–196).

Because the Amiga doesn't support resource files, an Amiga program must load a window data structure explicitly before calling the *OpenWindow* system routine, which actually creates the window (lines 69–91 in Listing Three). If the window is to appear in a custom screen rather than the default Workbench screen, the program must also first initialize a screen data structure and call *OpenScreen* (lines 52–68). Note that although it doesn't matter to the Macintosh whether windows or menus are created first, it does matter to the Amiga. Amiga menus are attached to windows, not to the screen, and therefore a menu strip is useless unless a window has previously been created to which it can be attached.

Event Trapping

Event trapping on the Macintosh and Amiga is similar in principle but somewhat different in detail. The general idea is to somehow let the computer know which events are of importance and then to enter a wait state until a desired event occurs. Once an event has been recorded, a program must identify which type of event has been posted and take action based on that particular event.

The Macintosh posts events to a system event queue. Events of interest to an application program (that is, those that aren't handled automatically by the system) are passed on to the program. An application program checks its queue repeatedly



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with the routine *GetNextEvent* (lines 62–65 in Listing One) to determine if an event has been posted. If *GetNextEvent* returns a Boolean result of *FALSE*, then the program simply branches to the top of the event loop (line 59) to check again. Assuming that an event has been posted, information about the event is stored in an event record. The program can then use information from that record to identify the exact type of event (see lines 69–74). In some cases, events not of interest to the application can appear in the event queue. When that occurs, the program simply ignores the event (line 75). When a desired event is identified, however, Macintosh programs generally branch to submodules, each of which processes a single event type. When the event has been handled, the program returns to the event loop to idle until another event is posted to the event queue.

The Amiga reports events via message ports, which must be initialized before they can be used. The *OpenWindow* routine creates an intuition message port, but ports must be created explicitly for the console device, which will be used for text I/O. The subroutine *CreatePort* (lines 278–307 in Listing Three) allocates a signal bit for a new port, allocates memory for the port's data structure, initializes a task control block for the port, and adds the port to the linked list of current message ports.

Amiga programs do not need a program loop to idle while waiting for an event. Instead, they can use the system routine *Wait*, which idles until a desired event occurs. *Wait* must be supplied with the signal bits assigned to each of the input ports that should be monitored for events. In the sample Amiga program, that includes the signal bit for the intuition message port and the signal bit for the console read port (see lines 184–193 in Listing Three).

Unlike the Macintosh, the Amiga doesn't report all types of events automatically. In line 77, the system is instructed to report only two of the types of events that may occur when this window is active—a click in the window close gadget and a selection from a menu. Therefore, any event detected by *Wait* should be an event useful to the program.

If a Macintosh program identifies a selection from a menu (a "mouse-down" event in the menu bar), the program is faced with the problem of identifying which item from which menu has been selected. A single system routine, *MenuSelect* (lines 125–127 in Listing One), returns both the menu's resource ID and the number of the menu item. *MenuSelect* uses a field from the event record as input—the coordinates of the mouse pointer when the selection was made. The menu number, returned in the high-order word of the long-word result, is then isolated from the menu item, which is returned in the low-order word (lines 128–130). Finally, the menu number can be used

(continued from page 47)

to identify the precise menu posting the event.

An Amiga program must also identify which menu and which item have been selected. The Amiga, though, reports only that an intuition event has occurred. The program must retrieve the input message with the system routine *GetMsg* (lines 205–208 in Listing Three) to determine exactly which of the intuition events requested in the window data structure has been detected. Once the type of event has been recovered (line 211), it can be compared against the desired types of events (lines 212–215) in the same way as the Macintosh program identifies events. The menu number and menu item (and the menu subitem, if applicable) are stored in a 16-bit field in the message data structure. The menu number is in bits 0–4 and can be isolated by masking off the 11 high-order bits (line 222). The menu item is in bits 5–10 (see lines 225–226).

The sample Macintosh program supports activities from all three menus. The Apple menu's desk accessories are handled by system routines. *GetItem* (lines 140–143 in Listing One) retrieves the name of the desk accessory that has been selected. *OpenDeskAcc* (lines 144–147) actually opens the program. Once the desk accessory has been opened, subsequent events in that program are posted to the event queue and detected as mouse-button down events in a system window (lines 104–105). In that case, the system routine *SystemClick* (lines 111–113) processes the event without further intervention from the application program. For the purposes of the sample program, only the Quit item is actually trapped from the File menu (lines 176–177); all other options simply return to the event loop. The *CloseAndQuit* routine (lines 187–191) frees the space used for text storage (*TEDispose* in lines 187–188), closes the window (*CloseWindow* in lines 189–190), and then returns to the Finder. The Edit menu, which is fully implemented with system routines, is discussed later in this article in the context of text editing.

The Amiga program also handles only the Quit item from its Project menu. Its *CloseAndQuit* routine (lines 229–240 in Listing Three) first removes any unprocessed console events with the system macro *ABORTIO* (this macro is found in the Amiga include files), then closes the console device (*CloseDevice* in lines 231–233), closes the window (*CloseWindow* in lines 234–236), and finally closes the custom screen (*CloseScreen* in lines 237–239) before returning to the operating system. The Edit menu is not implemented because the Amiga does not have system routines for text editing.

Text Editing

The environment for text editing is very, very different on the Macintosh and Amiga. Other writers have glossed over the Macintosh's text editing abilities (for example, see the September 1986 issue of *Byte* magazine[3]), but it is in this area that the difference between the Mac and Amiga system routines is glaringly apparent. The Macintosh's system routines for text editing are simple and elegant. The Amiga has nothing comparable; Amiga text I/O relies on low-level device communication.

To do text I/O, a Macintosh program allocates a text edit record with the system routine *TENew* (see lines 52–56 in Listing One). The text edit record is associated with a window, though the text stored in the text edit record can be much larger than what can be seen in the window at any given time. A call to *TEActivate* (lines 57–58) makes the text edit window active and draws the straight-line cursor as the text entry point. Repeated calls to *TEIdle* (line 61), usually within the program's event loop, ensure that the cursor blinks regularly.

When a text edit window is active, Macintosh programs generally assume that key-down events not associated with the command key represent text to be both displayed on the screen and stored in the text edit record. Whenever such an event is detected, the key pressed is stored in the event record. *TEKey* (lines 79–81 in Listing One) displays that character at the current cursor position, adjusting word wrap as necessary, and

inserts the character into the text edit record in RAM.

Mouse-down events in active text edit windows signal that the user wishes to either change the position of the straight-line cursor or identify a block of text for editing activities. The Macintosh refers to blocks of code or the straight-line cursor as the "selection range." Setting the selection range requires calls to two system routines. *GlobalToLocal* (lines 115–116) is a graphics routine that takes the point where the mouse-down event occurred, which is expressed in global screen coordinates, and translates it to the text edit window's local coordinate system. The transformed coordinates can then be passed to *TEClick* (lines 117–123), which actually sets the selection range.

The text editing functions listed in the Macintosh's standard Edit menu are each available as a single system routine that bases its operation on the current selection range. *TECut* (lines 156–159) deletes the current selection range from the screen, adjusting word wrap and the text edit record. The deleted text is stored in RAM in an area known as the "Clipboard." Cut, and any other operations that write to the Clipboard, erase the previous contents of the Clipboard. *TECopy* (lines 161–165) writes the current selection range to the Clipboard but does not affect the screen or text edit record. *TEPaste* (lines 166–169) inserts whatever it finds on the Clipboard at the current selection point (either at the straight-line cursor or after the selection range). Both the screen display and text edit record are adjusted. *TEClear* (lines 171–175) deletes the current selection range without affecting the Clipboard. These functions also provide "intelligent cut and paste," automatically adjusting spacing between words when text is either deleted, cut, or pasted.

There are two major ways to do text I/O on the Amiga—either via the console device, which processes keystrokes before passing them on to the system, or via the RAW device, which transmits unprocessed key codes. For simple text I/O, the console device is easier to use because it automatically manages special keys such as the backspace. To use the console device, an Amiga program must, as discussed earlier, allocate two message ports—one for input and one for output. These message ports are then incorporated into standard I/O request blocks, the data structures that are actually used for I/O. The subroutine *CreateStdIO* (lines 308–319, Listing Three) allocates memory for a standard I/O data structure and initializes the data structure with the address of its message port. Finally, the console device can be opened by the subroutine *OpenConsole* (lines 320–330). Note that the call to the system routine *OpenDevice* (line 327) returns a pointer to the device data structure in a field of one of the standard I/O request blocks. In other words, the device is linked to the I/O request blocks rather than the I/O request blocks being linked to the device. If the console is opened successfully, a solid block cursor appears in the upper left-hand corner of the window to which the console is attached. The cursor does not blink.

The system routine *SendIO*, which appears in the subroutine *QueueRead* (lines 332–337), issues a request for console input. *SendIO* uses data from the input standard I/O request block, including the type of operation to perform (line 332), the place where input should be stored (line 333), and the number of bytes to input (line 334).

The subroutine *ConPutChar* (lines 338–343) handles console output. Using the system routine *DoIO* (line 342), it displays a single character at the current cursor position and moves the cursor to the right. If the cursor is pushed past the right edge of the window, it drops to the leftmost position on the line below. *ConPutChar* does not do word wrap, nor does it store the text displayed in main memory. Subsequent calls to *QueueRead* reuse the same storage space for input characters. As mentioned before, the Amiga also has no system routines for text editing. Therefore, although the backspace key can erase whatever character is displayed to the left of the cursor, no other editing is possible. To implement the standard text editing functions, programmers must write their own routines to do word wrap, manipulate the selection range, store text in main memory (or on disk if applicable), manage a clipboard, and do the editing operations.

The Bottom Line

It might be unfair to base an evaluation of the system routines of the Macintosh and Amiga simply on the subset of the routines designed to manipulate the user interface. On the other hand, the programming strategies used to implement the standard user interfaces are similar to those required for other system operations. In general, the Macintosh routines isolate programmers from low-level tasks such as list manipulation and initialization of data structures (File Manager parameter blocks are notable exceptions). Although this reduces the burden placed on the programmer, it can decrease the programmer's flexibility. The Macintosh routines are also more complete in terms of their support for the documented user interface. The effect is again to reduce the burden placed on the programmer.

On the Amiga, the intuition library provides routines for the standard user interface. Although support for screen, windows, menus, and fonts is available, there is a great gap in terms of text editing. In other words, the Amiga does not provide system routines to fully implement its own standard interface recommendations. As someone who writes more programs that rely on text manipulation than on graphics, I believe that this is a serious deficiency. It is true that the Amiga performs some functions "automatically" for which a Macintosh program must include code (for example, moving and sizing windows). Nonetheless, the Macintosh does include system routines to handle those functions.

Notes

1. Caroline Rose et al., *Inside Macintosh* (Reading, Mass.: Addison-Wesley, 1985).

2. Robert J. Mical and Susan Deyl, *Intuition: The Amiga User Interface* (Commodore-Amiga Inc., 1985).

3. Adam Brooks Webber, "Amiga vs. Macintosh," *Byte* (September 1986): 249–257.

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(Listings begin on page 64.)

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Listing One *(Text begins on page 22.)*

```
; Listing One
; FLINT's system macros

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;                                                                       ;
;  MACRO definition file for FLINT as implemented on the               ;
;                       SAGE II microcomputer.                          ;
;                                                                       ;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

        .MACRO      XSTOP       ;   determines the environment (if any)
                                ;   into which the exit is made
        .WORD       4EF9H       ;
        .WORD       00FEH       ;   exit to PROM monitor/debugger
        .WORD       0030H       ;
        .ENDM

        .MACRO      TGET        ;   gets a character from the terminal
                                ;   and puts its ASCII value in the
                                ;   lower byte of D0
        .WORD       4EB9H       ;
        .WORD       00FEH       ;   PROM BIOS call
        .WORD       0008H       ;
        .ENDM

        .MACRO      TPUT        ;   sends the character whose ASCII value
                                ;   is in the lower byte of D0 to the
                                ;   terminal
        .WORD       4EB9H       ;
        .WORD       00FEH       ;   PROM BIOS call
        .WORD       0014H       ;
        .ENDM

        .MACRO      GETBLOCK            ;   loads 1024 bytes from the disk block
                                        ;   numbered by the value in CBLOCK into
                                        ;   a buffer whose address is DISKBUF
        MOVE.L      A4,-(A7)            ;   save A4
        MOVE.W      CBLOCK,-(A7)        ;   push block #
        LEA         DISKBUF,A0          ;
        MOVE.L      A0,-(A7)            ;   push buffer address
        MOVE.L      #1024,-(A7)         ;   push length of transfer (1024 bytes)
        MOVE.W      #1,-(A7)            ;   push drive #
        .WORD       4EB9H               ;
        .WORD       00FEH               ;   PROM BIOS call for diskread
        .WORD       0028H               ;
        MOVEA.L     (A7)+,A4            ;   recover A4
        .ENDM

        .MACRO      SAVBLOCK            ;   saves the contents of a 1024 byte
                                        ;   buffer whose address is DISKBUF onto
                                        ;   the disk block numbered by the value
                                        ;   in CBLOCK
        MOVE.L      A4,-(A7)            ;   save A4
        MOVE.W      CBLOCK,-(A7)        ;   push block #
        LEA         DISKBUF,A0          ;
        MOVE.L      A0,-(A7)            ;   push buffer address
        MOVE.L      #1024,-(A7)         ;   push length of transfer (1024 bytes)
        MOVE.W      #1,-(A7)            ;   push drive #
        .WORD       4EB9H               ;
        .WORD       00FEH               ;   PROM BIOS call for diskwrite
        .WORD       002CH               ;
        MOVEA.L     (A7)+,A4            ;   recover A4
        .ENDM
```

End Listing One

Listing Two

```
; Listing Two
; The FLINT Interpreter

        .NOLIST
        .NOSYMTABLE
        .NOMACROLIST
        .NOPATCHLIST
        .INCLUDE  MACROS.TEXT
        .LIST

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;                                                                                  ;
; FLINT     (Forth-Like INterpreter and Threader)                                  ;
;                                                                                  ;
;  We note the effect that the execution of a word has on the stack by a           ;
;  conventional shorthand. Before and after lists of the relevant stack            ;
;  parameters are given in "rightmost is topmost" order separated by               ;
;  "-->". An address is denoted by "a", an integer by "n", and a flag by           ;
;  "fl". Parameters in parentheses may or may not be present.                      ;
;                                                                                  ;
;    word              action                                  stack effects       ;
;                                                                                  ;
;   TOKEN  gets token from input buffer                                            ;
;                                                               _                  ;
;   SEARCH            searches dictionary for current token     a --> (a),fl       ;
;                     pushes its code address and true flag                        ;
;                     or else false flag                                           ;
;                                                                                  ;
;   EXECUTE           executes routine whose code address       a --> __           ;
;                     is on stack                                                  ;
;                                                                                  ;
;   NUMBER            determines if a token whose address is                       ;
;                     popped from stack represents a number     a --> (n),fl       ;
;                     if so pushes value and true flag or else                     ;
;                     pushes false flag                                            ;
```

```
;                                                                              ;
;    WHAZZAT           sends ? to terminal                           _         ;
;                                                                              ;
;    HEADER            makes a dictionary header for the next                  ;
;                      token in the input stream (the name of        _         ;
;                      a word being defined).                                  ;
;                                                                              ;
;    :                 calls HEADER and then sets the compile                  ;
;                      mode (colon) flag                                       ;
;                                                                              ;
;    COMPILE           writes code for JSR in the dictionary                   ;
;                      and calls "," (which furnishes the        a --> _       ;
;                      operand for JSR)                                        ;
;                                                                              ;
;    CODE   an "immediate" word (executed even in                              ;
;                      compile mode) which sets the base to hex      _         ;
;                      and sets the code submode flag                          ;
;                                                                              ;
;    ,                 takes a number from the stack and writes  n --> _       ;
;                      it in the dictionary directly                           ;
;                                                                              ;
;    LITERAL           takes a number from the stack and                       ;
;                      generates code which when executed will   n --> _       ;
;                      push the number back on the stack                       ;
;                                                                              ;
;    ;                 closes the current definition by writing                ;
;                      an RTS in the dictionary and clearing the     _         ;
;                      compile and code flags.                                 ;
;                                                                              ;
;    PROMPT            sends prompt (ok) to terminal                 _         ;
;                                                                              ;
;    LINE   gets a line from the input device and            --                ;
;                      places it in the line buffer                            ;
;                                                                              ;
; control structure of the prompt and input code                               ;
;                            PROMPT                                            ;
;                            LINE                                              ;
;                            outer interpreter loop                            ;
;                                   TOKEN                                      ;
;                                   SEARCH                                     ;
;                                   if found                                   ;
;                                      EXECUTE  (execute mode)                 ;
;                                      STKCHK                                  ;
;                                        or                                    ;
;                                      COMPILE  (compile mode)                 ;
;                                   else                                       ;
;                                      NUMBER                                  ;
;                                      if fail                                 ;
;                                           WHAZZAT                            ;
;                                      else                                    ;
;                                           COMMA  (code mode)                 ;
;                                            or                                ;
;                                           LITERAL    (compile mode)          ;
;                                            or                                ;
;                                           return     (execute mode)          ;
;                                                                              ;
; register usage                                                               ;
;                                                                              ;
;    A4      line buffer pointer                                               ;
;    A5      dictionary pointer              D0     I/O port                   ;
;    A6      parameter stack pointer         D1     "scratch                   ;
;    A7      return stack pointer            A0           registers"           ;
;                                                                              ;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

          .ABSOLUTE
          .PROC         FLINT
          .ORG          01000H

          BRA           START              ; set up

TERMBUF   .BLOCK        84,32              ;          system buffers,
DISKBUF   .BLOCK        1024,32
          .ASCII        "INTERACTIVE "
          .BYTE         13
          .BYTE         32

RTNSTK    .BLOCK        80,0               ;          system stacks,
PARMSTK   .BLOCK        256,0
UNDRFLW   .WORD         0

DICT      .WORD         LAST               ;          system variables,
CBLOCK    .WORD         0050H
BASE      .WORD         10

FCOLON    .BYTE         0                  ;          system flags,
FIMMED    .BYTE         0
FCODE     .BYTE         0
FNEG      .BYTE         0
FINT      .BYTE         0
          .ALIGN        2
BLANK     .BLOCK        4,32               ;          etc.
ZERO      .BLOCK        3,32
          .BYTE         48

START     LEA           RTNSTK+80,A7       ; initialize pointers
          LEA           PARMSTK+256,A6     ;
          MOVEA.W   BUFPNT,A5              ;
          CLR.L         FCOLON             ; initialize flags
          CLR.B         FINT               ;
          JSR           LOAD               ; load boot screen
RESTART   JSR           WHICHBUF           ; select input buffer

MAIN      JSR           TOKEN              ; get next token
          MOVE.W        DICT,-(A6)         ; push dictionary pointer
          JSR           SEARCH             ; look for token
          TST.W         (A6)+              ; if found then
          BEQ           TSTNUM             ;
          BCLR          #7,FIMMED          ;         if immediate flag off then
```

(continued on next page)

68000 MINI FORTH

Listing Two *(Listing continued, text begins on page 22.)*

```
          BNE       GODO          ;
          TST.B     FCOLON        ;       if in compile mode
          BEQ       GODO          ;
          JSR       COMPILE       ;         compile
          BRA       MAIN          ;   else
GODO      JSR       EXECUTE       ;       execute word
          JSR       STKCHK        ;       and check underflow
          BRA       MAIN          ; else

TSTNUM    MOVE.W    A5,-(A6)      ;   push token buffer address
          JSR       NUMBER        ;   is token a number ??
          TST.W     (A6)+         ;   if not
          BNE       TSTCODE       ;
          JSR       WHAZZAT       ;       ? whazzat ?
          BRA       MAIN          ;   else

TSTCODE   TST.B     FCODE         ;       if code flag on
          BEQ       TSTLIT        ;
          JSR       COMMA         ;          write code in dictionary
          BRA       MAIN          ;       else

TSTLIT    TST.B     FCOLON        ;          if in compile mode
          BEQ       MAIN          ;
          JSR       LITERAL       ;               compile number as literal
          BRA       MAIN          ;

WHICHBUF TST.B    FINT
          BNE       GOLINE        ; if not in interactive mode
          LEA       DISKBUF,A4    ;   get input from disk buffer
          RTS                     ; else

GOLINE    JSR       LINE          ;   fill line buffer from terminal
          RTS                     ;

LINE      JSR       PROMPT        ; prompt
          MOVEQ     #76,D1        ;
          LEA       TERMBUF,A4    ;
CLEANUP   MOVE.L    BLANK,0(A4,D1) ; clear line buffer
          SUBQ.B    #4,D1         ;
          BGE       CLEANUP       ;
          CLR.L     D1            ; clear character count
INCHAR    TGET                    ; get next character and
          CMPI.B    #13,D0        ;   do while not CR
          BEQ       EXIT          ;
          CMPI.B    #8,D0         ;   if character is backspace
          BNE       INBUF         ;
          JSR       RUBOUT        ;       rubout previous char
          BRA       INCHAR        ;   else
INBUF     MOVE.B    D0,0(A4,D1)   ;       copy it into buffer
          ADDQ.B    #1,D1         ;       increment count
          TPUT                    ;       echo to terminal
          BRA       INCHAR        ;
EXIT      MOVE.B    D0,1(A4,D1)   ; imbed CR in buffer
          RTS

RUBOUT    TST.B     D1            ; if count > 0 then
          BLE       RRET          ;
          TPUT                    ;   echo backspace
          SUBQ.B    #1,D1         ;   decrement count
          MOVEQ     #32,D0        ;   erase previous character...
          MOVE.B    D0,0(A4,D1)   ;   in buffer and ...
          TPUT                    ;   on terminal
          MOVEQ     #8,D0         ;
          TPUT                    ;
RRET      RTS                     ; return

STKCHK    LEA       UNDRFLW,A0    ;
          CMPA.W    A0,A6         ; if top is below bottom
          BLE       OKSTK         ;
          JSR       STKU          ;   underflow exception
OKSTK     RTS                     ;

NULLWORD .BLOCK     6,0           ;  DICTIONARY

          .BYTE     4
          .ASCII    "CRL"         ;   CRLF
          .WORD     NULLWORD
CRLF      MOVEQ     #13,D0
          TPUT                    ; send CR
          MOVEQ     #10,D0        ;
          TPUT                    ; send LF
          RTS                     ; return

          .BYTE     6
          .ASCII    "PRO"         ;   PROMPT
          .WORD     CRLF-6
PROMPT    JSR       CRLF          ; send CR LF
          MOVEQ     #111,D0       ;
          TPUT                    ; send "o"
          MOVEQ     #107,D0       ;
          TPUT                    ; send "k"
          MOVEQ     #32,D0        ;
          TPUT                    ; send space
          RTS                     ; return

          .BYTE     7
          .ASCII    "WHA"         ;   WHAZZAT
          .WORD     PROMPT-6
WHAZZAT   JSR       CRLF          ; send CR LF
          MOVE.W    A5,-(A6)      ; push token address
          ADDI.W    #1,(A6)       ;
          MOVE.B    (A5),-(A6)    ; push character count
          CLR.B     -(A6)         ; pad it to "word" length
          JSR       TYPE          ; type offending token
          BRA       RSET
STKU      JSR       CRLF          ; (underflow entry point)
          MOVEQ     #42,D0        ;
          TPUT                    ; send *
```

```
RSET      MOVEQ     #63,D0            ;
          TPUT                        ; send ?
          LEA       PARMSTK+256,A6    ; reset stack pointer
          CLR.L     FCOLON            ; initialize flags
          TAS       FINT              ; set interactive mode
          JSR       CR                ; get new line
          RTS

          .BYTE     5
          .ASCII    "TOK"             ;    TOKEN
          .WORD     WHAZZAT-6
TOKEN     CLR.L     (A5)              ; clear token buffer
          CLR.L     D1                ; clear count
GETCHAR   MOVE.B    (A4)+,D0          ; getcharacter until space
          CMPI.B    #32,D0            ;
          BEQ       EXITGET           ;
          MOVE.B    D0,1(A5,D1)       ;    place in token buffer
          ADDQ.B    #1,D1             ;    increment count
          BRA       GETCHAR           ;
EXITGET   MOVE.B    D1,(A5)           ; put count in 1st byte of buffer
          BEQ       GETCHAR           ; if count is 0 repeat
          RTS                         ; return

          .BYTE     129
          .BYTE     13                ;    (CR)
          .WORD     0
          .WORD     TOKEN-6
CR        LEA       RTNSTK+80,A7      ; reset system stack
          JMP       RESTART           ; restart

          .BYTE     6
          .ASCII    "SEA"             ;    SEARCH
          .WORD     CR-6
SEARCH    MOVE.L    (A5),D1           ; put token "stem" in D1
          MOVEA.W   A6,A0             ; use A0 as search pointer
COMPARE   TST.W     (A0)              ; DO
          MOVEA.W   (A0),A0           ;    get address of next word
          BEQ       NOFIND            ;    if nullword, exit NOFIND
          CMP.L     (A0),D1           ;    compare word to candidate
          BEQ       FIND              ;    if found, exit FIND
          BCHG      #31,D1            ;    set precedence bit
          CMP.L     (A0),D1           ;    compare to "immediate" candidate
          BEQ       FINDIMM           ;    if found, exit FINDIMM
          BCHG      #31,D1            ;    reset precedence bit
          LEA       4(A0),A0          ;    get link address
          BRA       COMPARE           ; LOOP
FINDIMM   TAS       FIMMED            ; set immediate flag
FIND      LEA       6(A0),A0          ; get code address
          MOVE.W    A0,(A6)           ; push it
          MOVE.W    #-1,-(A6)         ; push success flag
          RTS                         ;
NOFIND    MOVE.W    A0,(A6)           ; push fail flag
          RTS

          .BYTE     6
          .ASCII    "NUM"             ;    NUMBER
          .WORD     SEARCH-6
NUMBER    CLR.L     D2                ; clear conversion register
          MOVEA.W   (A6)+,A0          ; get token address
          MOVE.B    (A0)+,D1          ; get digit count
                                      ; DO
NXTDIG    MOVE.B    (A0)+,D0          ;    get next digit
          SUBI.B    #48,D0            ;    strip ASCII prefix
          BLT       FAIL              ;    if digit too small, FAIL
          CMP.W     #10,D0            ;    if digit > 9
          BLT       CMPBASE           ;         adjust for "odd" values
          SUBI.B    #7,D0             ;         and test again
          CMP.W     #10,D0            ;
          BLT       FAIL              ;
CMPBASE   CMP.W     BASE,D0           ;    if base < digit
          BGE       FAIL              ;         FAIL
          MULU      BASE,D2           ;    multiply current value by base
          SWAP      D2                ;
          TST.W     D2                ;    if overflow
          BNE       FAIL              ;         FAIL
          SWAP      D2                ;
          ADD.W     D0,D2             ;    add current digit
          BCS       FAIL              ;    if overflow, FAIL
          SUBQ.B    #1,D1             ;    decrement count
          BNE       NXTDIG            ; UNTIL no digits remain
          MOVE.W    D2,-(A6)          ; push number
          MOVE.W    #-1,-(A6)         ; push success flag
          RTS
FAIL      CLR.W     -(A6)             ; push fail flag
          RTS

          .BYTE     7
          .ASCII    "EXE"             ;    EXECUTE
          .WORD     NUMBER-6
EXECUTE   MOVEA.W   (A6)+,A0          ; pop code address
          JSR       (A0)              ; execute
          RTS

          .BYTE     7
          .ASCII    "COM"             ;    COMPILE
          .WORD     EXECUTE-6
COMPILE   MOVE.W    #04EB8H,(A5)+     ; compile "JSR"
          JSR       COMMA             ; compile code address
          RTS

          .BYTE     6
          .ASCII    "HEA"             ;    HEADER
          .WORD     COMPILE-6
HEADER    MOVE.W    DICT,4(A5)        ; link header to dictionary
          MOVE.W    A5,DICT           ; update DICT
          LEA       6(A5),A5          ; move pointer to code field
          RTS

          .BYTE     9
          .ASCII    "IMM"             ;    IMMEDIATE
          .WORD     HEADER-6
```

(continued on next page)

Listing Two *(Listing continued, text begins on page 22.)*

```
IMMED     MOVEA.W   DICT,A0          ; get address of most recent word
          TAS       (A0)             ; set precedence bit
          RTS

          .BYTE     1
          .ASCII    ":"              ;    ":"
          .WORD     0
          .WORD     IMMED-6
COLON     JSR       TOKEN            ; get token
          JSR       HEADER           ; make header
          TAS       FCOLON           ; set colon flag
          RTS

          .BYTE     132
          .ASCII    "COD"            ;    CODE
          .WORD     COLON-6
CODE      MOVE.W    #16,BASE         ; change BASE to hex
          TAS       FCODE            ; set code flag
          RTS

          .BYTE     129
          .ASCII    ";"              ;    ";"
          .WORD     0
          .WORD     CODE-6
SEMI      MOVE.W    #10,BASE         ; change BASE to decimal
          CLR.B     FCOLON           ; clear colon flag
          CLR.B     FCODE            ; clear code flag
          MOVE.W    #04E75H,(A5)+    ; compile "RTS"
          RTS

          .BYTE     1
          .ASCII    ","              ;    ","
          .WORD     0
          .WORD     SEMI-6
COMMA     MOVE.W    (A6)+,(A5)+      ; pop number to dictionary
          RTS

          .BYTE     7
          .ASCII    "LIT"            ;    LITERAL
          .WORD     COMMA-6
LITERAL   MOVE.W    #03D3CH,(A5)+    ; compile literal code
          JSR       COMMA            ; compile constant
          RTS

          .BYTE     11
          .ASCII    "INT"            ;    INTERACTIVE
          .WORD     LITERAL-6
INTRACTV TAS        FINT             ; set interactive mode
          RTS

          .BYTE     4
          .ASCII    "BAS"            ;    BASE
          .WORD     INTRACTV-6
BASECODE LEA        BASE,A0          ; push BASE address
          MOVE.W    A0,-(A6)
          RTS

          .BYTE     6
          .ASCII    "CBL"            ;    CBLOCK
          .WORD     BASECODE-6
CBLCODE   LEA       CBLOCK,A0        ; push CBLOCK address
          MOVE.W    A0,-(A6)
          RTS

          .BYTE     5
          .ASCII    "EDB"            ;    EDBUF
          .WORD     CBLCODE-6
EDBCODE   LEA       DISKBUF,A0       ; get edit buffer address
          MOVE.W    A0,-(A6)         ; push it
          RTS

          .BYTE     4
          .ASCII    "DIC"            ;    DICT
          .WORD     EDBCODE-6
DICTCODE LEA        DICT,A0          ; get dictionary address
          MOVE.W    A0,-(A6)         ; push it
          RTS

          .BYTE     4
          .ASCII    "LOA"            ;    LOAD
          .WORD     DICTCODE-6
LOAD      GETBLOCK                   ; system dependent macro
          RTS

          .BYTE     2
          .ASCII    "GO"             ;    GO
          .BYTE     0
          .WORD     LOAD-6
GO        CLR.B     FINT             ; leave interactive mode
          JSR       CR               ; restart input sequence

          .BYTE     4
          .ASCII    "SAV"            ;    SAVE
          .WORD     GO-6
SAVE      SAVBLOCK                   ; system dependent macro
          RTS

          .BYTE     4
          .ASCII    "TYP"            ;    TYPE
          .WORD     SAVE-6
TYPE      MOVE.W    (A6)+,D1         ; get character count
          SUBQ.B    #1,D1            ;
          MOVEA.W   (A6)+,A0         ; get buffer address
PUT       MOVE.B    (A0)+,D0         ; DO
          TPUT                       ;    send buffer character
          .WORD     51C9H            ;    to terminal
          .WORD     0FFF6H           ; UNTIL exhausted
          RTS
```

(continued on page 58)

Listing Two *(Listing continued, text begins on page 22.)*

```
         .BYTE       1
         .ASCII      "."                        ;     "."
         .WORD       0
         .WORD       TYPE-6
PRINT    MOVEQ       #13,D0                     ; send CR
         TPUT                                   ;
         MOVEQ       #10,D0
         TPUT
         MOVEA.W  A5,A0                         ; get buffer pointer
         MOVE.L      BLANK,(A0)+                ;
         MOVE.L      BLANK,(A0)+                ; zero out buffer
         MOVE.L      BLANK,(A0)+                ;
         MOVE.L      ZERO,(A0)+                 ;
         MOVE.W      (A6)+,D2                   ; pop number
         BGE         DLOOP                      ; if negative
         NEG.W       D2                         ;    make positive
         TAS         FNEG                       ;    set negative flag
DLOOP    ANDI.L      #65535,D2                  ; while quotient not 0 do
         BEQ         TSTMINUS                   ;    clear remainder
DIV      DIVS        BASE,D2                    ;    divide by base
         MOVE.L      D2,D0                      ;    (do dirty work in D0)
         SWAP        D0                         ;    get remainder
         CMPI.B      #10,D0                     ;
         BLT         PREFIX                     ;    convert to digit
         ADDQ.B      #7,D0                      ;
PREFIX   ADDI.B      #48,D0                     ;    make ASCII prefix
         MOVE.B      D0,-(A0)                   ;    place digit in buffer
         BRA         DLOOP                      ;
TSTMINUS BCLR        #7,FNEG                    ; test and clear negative flag
         BEQ         PRNT                       ; if set
         MOVE.B      #45,-(A0)                  ;    put minus sign in buffer
PRNT     MOVE.W      A5,-(A6)                   ; push buffer address
         MOVE.W      #16,-(A6)                  ; push buffer length
         JSR         TYPE                       ; type number
         RTS

         .BYTE       2
         .ASCII      ".S"                       ;     .S
         .BYTE       0
         .WORD       PRINT-6
SPRINT   LEA         UNDRFLW,A1                 ; get address of bottom
         MOVEA.W  A6,A2                         ;
BOTTOM   CMPA.W      A1,A2                      ; while above bottom do
         BEQ         DONE                       ;
         MOVE.W      (A2)+,-(A6)                ;    push next number
         JSR         PRINT                      ;    print it
         BRA         BOTTOM                     ;
DONE     RTS

         .BYTE       129
         .ASCII      "("                        ;     "("
         .WORD       0
         .WORD       SPRINT-6
CMMNT    MOVE.B      (A4)+,D0                   ; get character from input buffer
         CMPI.B      #41,D0                     ; until ")"
         BNE         CMMNT                      ;
         RTS

         .BYTE       4
         .ASCII      "QUI"                      ;     QUIT
         .WORD       CMMNT-6
QUIT     XSTOP                                  ; return to monitor
         RTS

LAST     .BYTE       6
         .ASCII      "LOG"                      ;     LOGOFF
         .WORD       QUIT-6
         LEA         BUFPNT,A0                  ; save dictionary pointer
         MOVE.W      A5,(A0)
         RTS

BUFPNT   .WORD       BUFFER
BUFFER   .WORD
         .END
```

End Listing Two

Listing Three

```
(Listing Three)
("inner shell" words for FLINT)

(The "->" symbol when used in a comment signifies that the)
(instruction corresponding to the preceding assembler)
(mnemonic will be written in the dictionary at execution time.)

: CONSTANT   ( n --                creates a constant)
  TOKEN HEADER LITERAL CODE 3AFC 4E75  ( rts  -> ) ;

: CREATE     ( --        creates the header and code body for a variable)
  TOKEN HEADER CODE 2AFC 41FA 0006  ( lea      6[a5],a0        -> )
                         3AFC 3D08          ( move.w   a0,-[a6]         -> )
                         3AFC 4E75          ( rts  -> ) ;

: ALLOT          ( n -- _           used after CREATE to allocate space for a )
                 (                  variable or an array                        )
  CODE DADE  ( ADDA.W          [A6]+,A5   ) ;

: VARIABLE   ( --        creates a variable)
  CREATE 2 ALLOT ;

: @              ( a -- n           "fetch" - replaces an address with its value)
  CODE 305E  ( MOVEA.W         [A6]+,A0   )
       3D10  ( MOVE.W          [A0],-[A6] ) ;
```

```
: !              ( n a -- _          stores a word length value in the address)
  CODE 305E  ( MOVEA.W               [A6]+,A0   )
       309E  ( MOVE.W                [A6]+,[A0] ) ;

: !BYTE          ( n a -- _          stores a byte length value in the address)
  CODE 305E  ( MOVEA.W              [A6]+,A0   )
       4A1E  ( TST.B [A6]+                     )
       109E  ( MOVE.B               [A6]+,[A0] ) ;

: HEX            ( --      changes the system base to 16)
  16 BASE ! ;

: DECIMAL      ( --        changes the system base to 10)
  10 BASE ! ;

: SWAP           ( n1 n2 -- n2 n1                   )
  CODE 221E  ( MOVE.L             [A6]+,D1 )
       4841  ( SWAP  D1                    )
       2D01  ( MOVE.L             D1,-[A6] ) ;

: DUP            ( n -- n n )
  CODE 3D16  ( MOVE.W              [A6],-[A6] ) ;

: ?              ( n -- _            tests the top value, drops it, and sets CCs)
  CODE 4A5E  ( TST.W [A6]+         ) ;

: \              ( n -- _            synonym for "?"   used to emphasize the drop)
  CODE 4A5E  ( TST.W [A6]+         ) ;

: OVER           ( n1 n2 -- n1 n2 n1 )
  CODE 3D2E 0002  ( MOVE.W   2[A6],-[A6] ) ;

: 2DUP           ( n1 n2 -- n1 n2 n1 n2 )
  OVER OVER ;

: >R             ( n -- _            removes a value from the parameter stack )
                 (                   and places it on the return stack         )
  CODE 221F  ( MOVE.L            [A7]+,D1 )
       3F1E  ( MOVE.W            [A6]+,-[A7] )
       2F01  ( MOVE.L            D1,-[A7] ) ;

: <R             ( _ -- n            removes a value from the return stack     )
                 (                   and places it on the parameter stack      )
  CODE 221F  ( MOVE.L            [A7]+,D1 )
       3D1F  ( MOVE.W            [A7]+,-[A6] )
       2F01  ( MOVE.L            D1,-[A7] ) ;

: ROT            ( n1 n2 n3 -- n2 n3 n1 )
  >R SWAP <R SWAP ;

: +              ( n1 n2 -- n1+n2 )
  CODE 321E  ( MOVE.W              [A6]+,D1 )
       D356  ( ADD.W D1,[A6]     ) ;

: ~              ( n -- -n )
  CODE 4456  ( NEG.W [A6] ) ;

: -              ( n1 n2 -- n1-n2 )
  ~ + ;

: *              ( n1 n2 -- n1*n2 )
  CODE 321E  ( MOVE.W              [A6]+,D1 )
       C3DE  ( MULS  [A6]+,D1 )
       3D01  ( MOVE.W              D1,-[A6] ) ;

: /MOD           ( n1 n2 -- n1/n2 n1 mod n2 )
  CODE 321E  ( MOVE.W              [A6]+,D1 )
       341E  ( MOVE.W              [A6]+,D2 )
       48C2  ( EXT.L D2                     )
       85C1  ( DIVS  D1,D2                  )
       3D02  ( MOVE.W              D2,-[A6] )
       4842  ( SWAP  D2                     )
       3D02  ( MOVE.W              D2,-[A6] ) ;

: /              ( n1 n2 -- n1/n2 )
  /MOD \ ;

: MOD            ( n1 n2 -- n1 mod n2 )
  /MOD SWAP \ ;

: 0<             ( n -- f        returns a true flag if n < 0)
  CODE 4A56               ( TST.W [A6]          )
       6D04               ( BLT   4[PC]         )
       4256               ( CLR.W [A6]          )
       4E75               ( RTS                 )
       3CBC FFFF    ( MOVE.W    #-1,[A6] ) ;

: 0>             ( n -- f        returns a true flag if n > 0)
  ~ 0< ;

: <              ( n1 n2 -- f   returns a true flag if next < top)
  - 0< ;

: >              ( n1 n2 -- f   returns a true flag if next > top)
  - 0> ;

: CGET           ( _ -- n            gets a character from the terminal and)
                 (                   places its ASCII value on the stack     )
  CODE 4EB9 00FE 0008  ( TGET                    )
       3D00                ( MOVE.W        D0,-[A6] ) ;

: EMIT           ( n -- _            takes an ASCII value from the stack and)
                 (                   sends it to the terminal                 )
  CODE 301E                ( MOVE.W        [A6]+,D0 )
       4EB9 00FE 0008  ( TPUT                 ) ;

: CLEAR          ( --      erases the screen)
  26 EMIT ;

: ->             ( --      increments CBLOCK; loads and executes )
                 (                   the new block [allows chaining]        )
```

(continued on page 61)

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Listing Three *(Listing continued, text begins on page 22.)*

```
  CBLOCK @  2 +       CBLOCK !  LOAD       GO ;

: ?>             ( -- )
  CODE 3AFC 4A5E  ( tst.w    [a6]+  -> ) ;

: BRA>           ( -- )
  CODE 3AFC 6000  ( bra            -> ) ;

: BEQ>           ( -- )
  CODE 3AFC 6700  ( beq            -> ) ;

: BNE>           ( -- )
  CODE 3AFC 6600  ( bne            -> ) ;

: MARK           (      _ -- a          pushes the contents of the dictionary pointer)
  CODE 3D0D  ( MOVE.W          A5,-[A6] ) ;

: SPLIT          (      _ -- a )
  ?> BEQ> MARK 2 ALLOT ;

: JOIN           ( -- )
  DUP MARK SWAP - SWAP ! ;

: IF             ( :  _ -- a   x  f -- _ )
  SPLIT ; IMMEDIATE

: THEN           ( :  a -- _   x  -- )
  JOIN ; IMMEDIATE

: ELSE           ( :  a1 -- a2   x         -- )
  BRA> MARK 2 ALLOT SWAP JOIN ; IMMEDIATE

: DO             ( :  _ -- a   x  -- )
  MARK ; IMMEDIATE

: UNTIL          ( :  a -- _   x  f -- _ )
  ?> BNE> MARK - , ; IMMEDIATE

: WHILE          ( :  _ -- a   x  f -- _ )
  SPLIT ; IMMEDIATE

: LOOP           ( :  a1 a2 -- _   x  -- )
  BRA> SWAP MARK - , JOIN ; IMMEDIATE

: '              ( _ -- a         pushes the address of the token which follows ')
  TOKEN DICT @ SEARCH IF ELSE WHAZZAT THEN ;

: FORGET     ( --     erases the dictionary entries for the token following)
                 (                FORGET as well as all tokens which succeed it in the )
                 (                dictionary                                            )
  ' DUP 2 - @  DICT !  6 - CODE 3A5E ( MOVEA.W      (A6)+,A5 ) ;
```

End Listings

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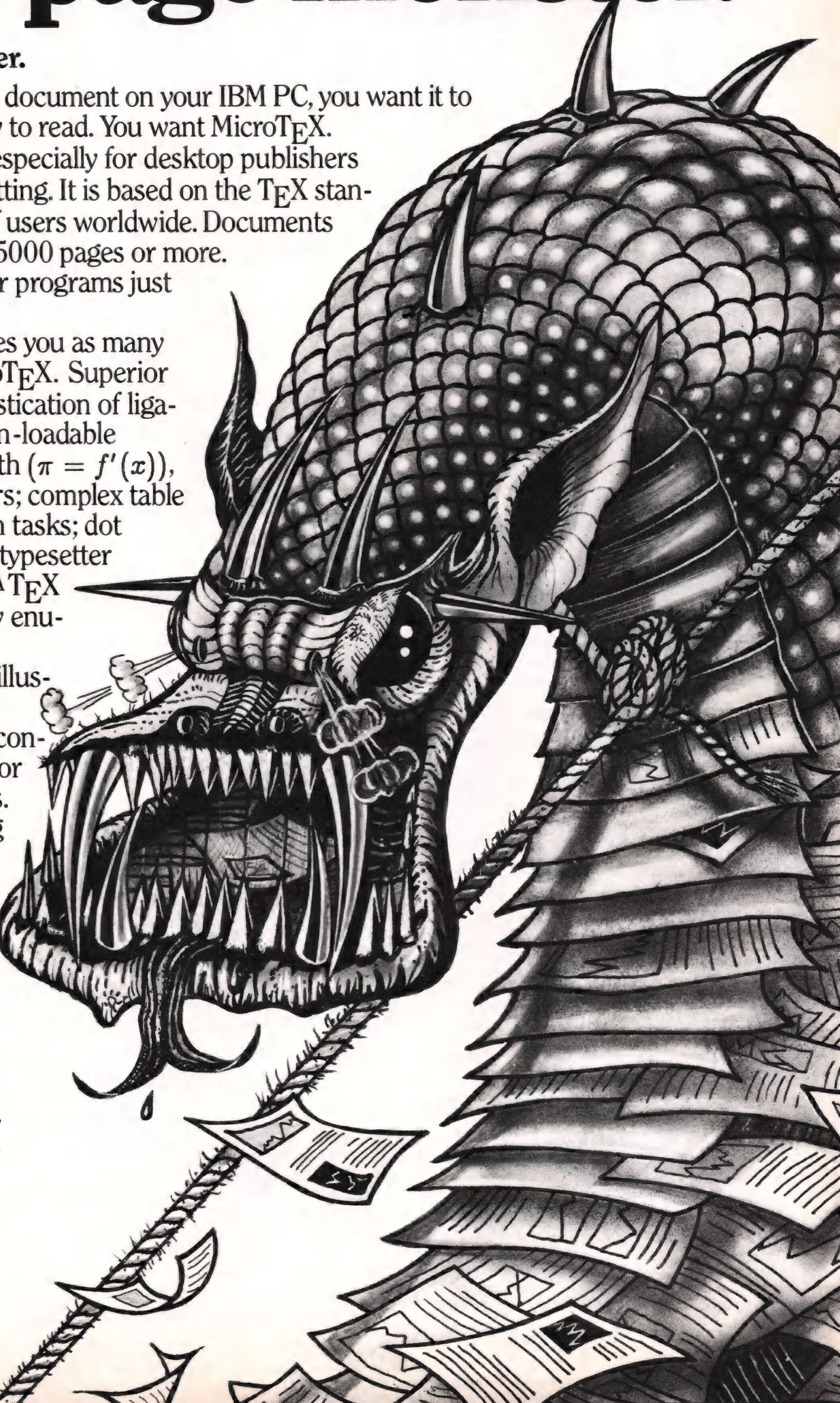

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Listing One *(Text begins on page 40.)*

```
Listing One

              Include   MacTraps.D
              Include   ToolEqu.D
              Include   SysEqu.D
              Include   QuickEqu.D

              PEA       -4(A5)                    ; initialize managers
              _InitGraf
              _InitFonts
              MOVE.L    #$0000FFFF,D0
              _FlushEvents
              _InitWindows
              _InitMenus
              CLR.L     -(SP)
              _InitDialogs
              _InitCursor

              CLR       -(SP)
              PEA       'DrD.Rsrc'
              _OpenResFile                        ;open resource file
              MOVE      (SP)+,D0                  ;discard unused result
;--------------------------- Set up menus ------------------------------
              CLR.L     -(SP)                     ;space for handle
              MOVE      #1,-(SP)                  ;menu ID
              _GetRMenu                           ;get Apple menu template
              MOVE.L    (SP)+,AppleHandle(A5)     ;retrieve & store handle

              MOVE.L    AppleHandle(A5),-(SP)     ;put handle back on stack
              MOVE.L    #'DRVR',-(SP)             ;res type for desk accs
              _AddResMenu                         ;get desk accessories

              MOVE.L    AppleHandle(A5),-(SP)
              CLR       -(SP)                     ;put menu after all others
              _InsertMenu                         ;put menu in menu list

              CLR.L     -(SP)                     ;repeat for other menus
              MOVE      #2,-(SP)
              _GetRMenu
              MOVE.L    (SP)+,FileHandle(A5)

              MOVE.L    FileHandle(A5),-(SP)
              CLR       -(SP)
              _InsertMenu

              CLR.L     -(SP)
              MOVE      #3,-(SP)
              _GetRMenu
              MOVE.L    (SP)+,EditHandle(A5)

              MOVE.L    EditHandle(A5),-(SP)
              CLR       -(SP)
              _InsertMenu

              _DrawMenuBar

; ------------------ Open the window with a text edit record -------------
              CLR.L     -(SP)                     ;space for window pointer
              MOVE      #1,-(SP)                  ;window ID
              PEA       WindowStorage(A5)         ;window storage
              MOVE.L    #-1,-(SP)                 ;put window in front
              _GetNewWindow
              MOVE.L    (SP)+,WindowPtr(A5)

              MOVE.L    WindowPtr(A5),-(SP)
              _SetPort                            ;makes window current grafport

              CLR.L     -(SP)                     ;place for text handle
              PEA       DestRect                  ;destination rectangle
              PEA       ViewRect                  ;view rectangle
              _TENew                              ;establish text edit record
              MOVE.L    (SP)+,TextHandle(A5)      ;get handle

              MOVE.L    TextHandle(A5),-(SP)
              _TEActivate                         ;make text edit record active
; ------------------ Event loop begins here ------------------------------
        Event
              _SystemTask                         ;update desk accessories
              MOVE.L    TextHandle(A5),-(SP)
              _TEIdle                             ;make cursor blink

              CLR       -(SP)                     ;space for boolean result
              MOVE      #-1,-(SP)                 ;mask to select all events
              PEA       EventRecord(A5)           ;pointer to event record
              _GetNextEvent                       ;get event from queue

              MOVE      (SP)+,D0                  ;retrieve boolean result
              BEQ       Event                     ;no event

              MOVE      EventRecord(A5),D0        ;get event type
```

(continued on page 66)

Listing One *(Listing continued, text begins on page 40.)*

```
                CMP     #mButDwnEvt,D0              ;mouse event?
                BEQ     MouseEvent

                CMP     #keyDwnEvt,D0               ;key pressed?
                BEQ     KeyEvent

                CMP     #upDatEvt,D0
                BEQ     Update                      ;refresh?

                BRA     Event                       ;no desired event posted

;------------------------ Handle key down events -------------------------
        KeyEvent
                MOVE    EventRecord+evtMeta(A5),D0
                BTST    #cmdKey,D0                  ;command key pressed?
                BNE     KeyboardEquivalent

                MOVE    EventRecord+evtMessage+2(A5),-(SP)  ;character pressed
                MOVE.L  TextHandle(A5),-(SP)
                _TEKey                              ;insert character

                BRA     Event

        KeyboardEquivalent
                CLR.L   -(SP)                       ;place for menu ID & item nubmer
                MOVE    EventRecord+evtMessage+2(A5),-(SP)  ;character
                _MenuKey                            ;which menu?

                BRA     Selections

;------------------------- Update the text window ------------------------
        Update
                MOVE.L  WindowPtr(A5),-(SP)
                _BeginUpdate

                MOVE.L  WindowPtr(A5),-(SP)
                _SetPort

                PEA     ViewRect
                MOVE.L  TextHandle(A5),-(SP)
                _TEUpdate

                MOVE.L  WindowPtr(A5),-(SP)
                _EndUpdate

                BRA     Event

;------------------------- Handle mouse down events ----------------------
        MouseEvent
                CLR     -(SP)                       ;space for "what" result
                MOVE.L  EventRecord+evtMouse(A5),-(SP) ;place where event occurred
                PEA     WhichWindowPtr(A5)  ;window affected goes here
                _FindWindow                         ;get exact location of event
                MOVE     (SP)+,D0                   ;recover result

                CMP     #inMenuBar,D0               ;in menu bar?
                BEQ     MenuBar

                CMP     #inSysWindow,D0             ;in desk accessory?
                BEQ     SysEvent

                CMP     #inContent,D0               ;in text edit area?
                BEQ     ApplWindow

                CMP     #inGoAway,D0                ;in close box?
                BEQ     GoAwayBox

                BRA     Event                       ;not an event this program handles

;--------------- Handle events in system windows -------------------
        SysEvent
                PEA     EventRecord(A5)
                MOVE.L  WhichWindowPtr(A5),-(SP)    ;window posting event
                _SystemClick                        ;let system handle it

                BRA     Event

;------------------- Handle events in content area of window -----------
        ApplWindow
                PEA     EventRecord+evtMouse(A5)    ;event location
                _GlobalToLocal                      ;convert coordinates

                MOVE.L  EventRecord+evtMouse(A5),-(SP)  ;coordinates now local
                MOVE    EventRecord+evtMeta(A5),D0
                BTST.L  #shiftKey,D0                ;extended selection?
                SNE     D0
                MOVE.B  D0,-(SP)                    ;extend or not extend
                MOVE.L  TextHandle(A5),-(SP)
                _TEClick                            ;set selection range

                BRA     Event
```

(continued on page 68)

Circle **no. 173** on reader service card.

Listing One *(Listing continued, text begins on page 40.)*

```
;---------------- Handle events in menu bar -----------------------
        MenuBar
                CLR.L     -(SP)                          ;space for menu ID & item
                MOVE.L    EventRecord+evtMouse(A5),-(SP) ;place where event occurred
                _MenuSelect                              ;get menu ID & item

        Selections
                MOVE.L    (SP)+,D7  ;recover result
                MOVE      D7,D6                ;D6 now has menu item
                SWAP      D7                   ;low-order word has menu ID

                CLR       -(SP)                ;selects all menus
                _HiLIteMenu                    ;remove highlighting

                CMP       #1,D7                ;apple menu?
                BEQ       AppleMenu

                CMP       #2,D7                ;file menu?
                BEQ       FileMenu

                CMP       #3,D7                ;edit menu?
                BEQ       EditMenu

                BRA       Event

;------------- Handle desk accessories ----------------------------
        AppleMenu
                MOVE.L    AppleHandle(A5),-(SP)
                MOVE      D6,-(SP)  ;menu item
                PEA       DeskAccName(A5)      ;space for desk accessory name
                _GetItem

                CLR       -(SP)                ;space for reference number
                PEA       DeskAccName(A5)      ;desk accessory name
                _OpenDeskAcc                   ;open the desk accessory
                MOVE      (SP)+,D0             ;discard result

                BRA       Event

;------------------- Handle editing --------------------------------
        EditMenu
                SUBQ      #1,D6                ;adjust item selected for SysEdit
                CLR       -(SP)                ;space for result
                MOVE      D6,-(SP)             ;adjusted item number
                _SysEdit

                MOVE      (SP)+,D0             ;get result
                BNE       Event                ;system handled edit

                ADDQ      #1,D6                ;restore item nuamber
                CMP       #3,D6                ;cut?
                BNE       EditMenu2
                MOVE.L    TextHandle(A5),-(SP)
                _TECut
                BRA       Event

        EditMenu2
                CMP       #4,D6                ;copy?
                BNE       EditMenu3
                MOVE.L    TextHandle(A5),-(SP)
                _TECopy
                BRA       Event

        EditMenu3
                CMP       #5,D6                ;paste?
                BNE       EditMenu4
                MOVE.L    TextHandle(A5),-(SP)
                _TEPaste
                BRA       Event

        EditMenu4
                CMP       #6,D6                ;clear?
                BNE       Event
                MOVE.L    TextHandle(A5),-(SP)
                _TEDelete
                BRA       Event

;--------------- Handle file menu ---------------------------------
        FileMenu
                CMP       #2,D6                ;close selected?
                BEQ       CloseAndQuit

                CMP       #4,D6
                BEQ       CloseAndQuit         ;quit selected

;!!!!!all other file menu options are not implemented in this program!!!!

                BRA       Event

;---------------- Close the window and quit ---------------------
        GoAwayBox
```

```
            CLR.B      -(SP)                        ;space for boolean result
            MOVE.L     WhichWindowPtr(A5),-(SP)     ;window pointer
            MOVE.L     EventRecord+evtMouse(A5),-(SP)      ;point of event
            _TrackGoAway                   ;monitor GoAway box

            MOVE.B     (SP)+,D0  ;get result
            BEQ        Event               ;don't close

    CloseAndQuit
            MOVE.L     TextHandle(A5),-(SP)
            _TEDispose                     ;close text edit record

            MOVE.L     WindowPtr(A5),-(SP)
            _CloseWindow                   ;close the window

            RTS                            ;return to Finder

;--------------------- Data structures ---------------------------
    AppleHandle        DS.L     1
    FileHandle         DS.L     1
    EditHandle         DS.L     1

    WindowPtr DS.L     1
    WindowStorage      DS       WindowSize

    TextHandle         DS.L     1
    ViewRect  DC       3,3,300,490
    DestRect  DC       3,3,300,490

    EventRecord        DS.B     16
    WhichWindowPtr     DS.L     1
    DeskAccName        DS       16
```

End Listing One

Listing Two

```
Listing Two

        DrD.Rsrc

        TYPE MENU ;menu templates follow
         ,1       ;resource ID
        \14       ;will create Apple icon for title

         ,2       ;resource ID
        File      ;menu title
        New/N     ;all the rest are menu items
        Open/O
        Close/W
        Save As...
        Save/S
        Page Setup...
        Print/P
        Quit/Q

         ,3       ;resource ID
        Edit      ;menu title
        Undo/Z
        (-        ;straight line - disabled
        Cut/X
        Copy/C
        Paste/V
        Clear

        TYPE WIND           ;window templates follow
         ,1                 ;resource ID
        Dr. Dobb's Journal  ;window title
        50 10 310 502       ;initial coordinates
        Visible GoAway      ;make window visible, draw GoAway box
        0                   ;window type (standard document window)
        0                   ;optional reference number
```

End Listing Two

Listing Three

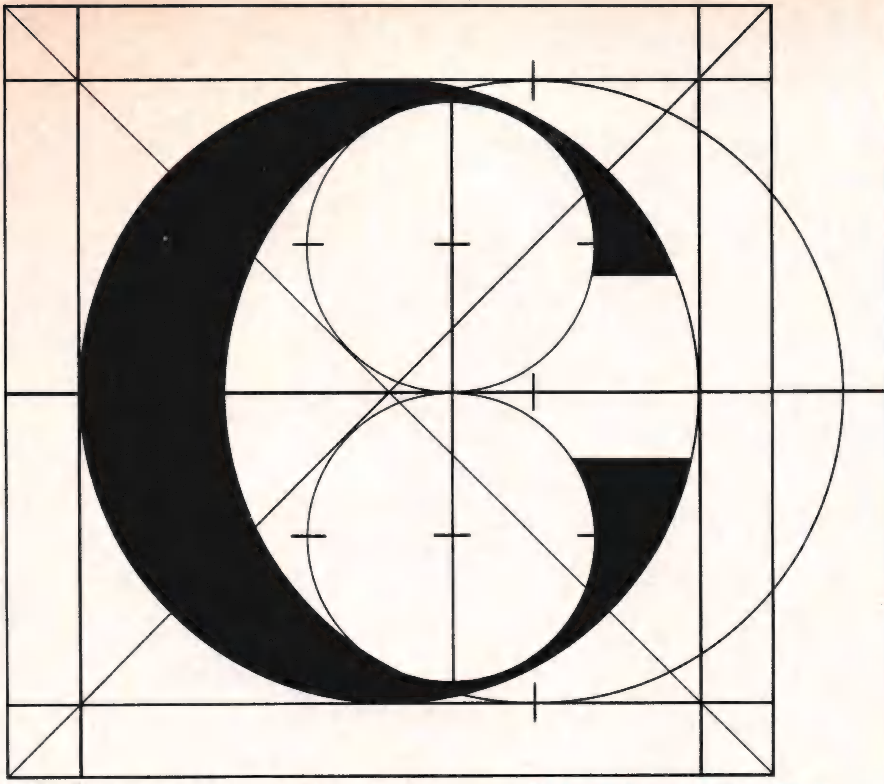
```
Listing Three

                include   "exec/types.i"
                include   "exec/exec.i"
                include   "intuition/intuition.i"

        callsys macro
                CALLIB    _LVO\1    ;calls a system routine
                endm

        xlib    macro
                xref      _LVO\1    ;for library routines
                endm
```

(continued on page 70)

Listing Three *(Listing continued, text begins on page 40.)*

```
        passtext macro
                lea       \1,A0     ;pointer to text
                lea       \2,A1     ;ptr to Intuition text structure
                jsr       SetText   ;initializes text structure
                endm

        passitem macro
                lea       \1,A0     ;pointer to menu item structure
                move.l    \2,A1     ;pointer to next menu item in list
                lea       \3,A2     ;pointer to text structure
                move.b    \4,D0     ;keyboard equivalent
                move      \5,D1     ;offset from top of menu item box
                jsr       SetItem   ;initializes menu item structure
                endm

                xlib      AllocSignal ;external refs for all system
                xlib      AllocMem  ;routines that the program will call
                xlib      FreeSignal
                xlib      AddPort
                xlib      NewList
                xlib      FindTask
                xlib      OpenLibrary
                xlib      OpenWindow
                xlib      SetMenuStrip
                xlib      OpenDevice
                xlib      DoIO
                xlib      SendIO
                xlib      Wait
                xlib      GetMsg
                xlib      ReplyMsg
                xlib      CloseDevice
                xlib      CloseWindow
                xlib      CloseScreen
                xref      _AbsExecBase ;exec's base is fixed

        FrontPen equ      0
        BackPen  equ      1         ;for rendering window and text

;---------------- Open Intuition library ----------------------------
                move.l    _AbsExecBase,A6
                lea       IntName,A1          ;name of library to open
                move.l    #0,D0
                callsys   OpenLibrary
                bne       Continue
                rts                 ;unsuccessful opening ends program

        Continue clr.l    IntBase
                move.l    D0,IntBase          ;save base of Intuition library

;------------------- Create a custom screen -------------------------
                lea       TheScreen,A0        ;pointer to screen data structure
                move      #0,ns_LeftEdge(A0) ;coordinates of screen
                move      #0,ns_TopEdge(A0)
                move      #320,ns_Width(A0)
                move      #200,ns_Height(A0)
                move      #2,ns_Depth(A0)     ;graphics depth
                move.b    #0,ns_DetailPen(A0) ;color for details
                move.b    #1,ns_BlockPen(A0)  ;color for rest of drawing
                move      #0,ns_ViewModes(A0)
                move      #CUSTOMSCREEN,ns_Type(A0)
                move.l    #0,ns_Fonts(A0)     ;use default font
                lea       ScreenTitle,A1
                move.l    A1,ns_DefaultTitle(A0)
                move.l    #0,ns_Gadgets(A0)   ;no special gadgets attached
                move.l    IntBase,A6
                callsys   OpenScreen
                move.l    D0,ScreenPtr        ;results almost always come back in D0

;----------------------- Open a window ------------------------------
                lea       TheWindow,A0        ;pointer to window data structure
                move      #20,nw_LeftEdge(A0)           ;initial coordinates
                move      #20,nw_TopEdge(A0)
                move.b    #0,nw_DetailPen(A0)           ;color for characters
                move.b    #1,nw_BlockPen(A0)  ;color for rest of drawing
                lea       WindowTitle,A1
                move.l    A1,nw_Title(A0)
                move.l    #WINDOWCLOSE+SMART_REFRESH+ACTIVATE+WINDOWDRAG+
                          WINDOWSIZING+WINDOWDEPTH,nw_Flags(A0)
                                              ;system gadgets, etc.
                move.l    #CLOSEWINDOW+MENUPICK,nw_IDCMPFlags(A0)
                                              ;events to be reported
                move      #CUSTOMSCREEN,nw_Type(A0)
                move.l    #0,nw_FirstGadget(A0)  ;no special gadgets attached
                move.l    #0,nw_CheckMark(A0) ;not using checked menu items
                move      #150,nw_Height(A0)  ;initial
                move      #280,nw_Width(A0)   ;initial
                move      #100,nw_MinWidth(A0) ;since window can be sized
                move      #25,nw_MinHeight(A0)
                move      #640,nw_MaxWidth(A0)
                move      #200,nw_MaxHeight(A0)
                move.l    ScreenPtr,nw_Screen(A0)
                move.l    IntBase,A6
```

(continued on page 72)



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Listing Three *(Listing continued, text begins on page 40.)*

```
                callsys  OpenWindow
                lea      WindowPtr,A0
                move.l   D0,(A0)
;-------------- Set up the menus ------------------------------
                passtext ProjText1,Proj1     ;First must initialize all
                passtext ProjText2,Proj2     ;Intuition text structures.
                passtext ProjText3,Proj3
                passtext ProjText4,Proj4
                passtext ProjText5,Proj5
                passtext ProjText6,Proj6
                passtext ProjText7,Proj7

                lea      ProjItem2,A3        ;Then must include the text
                passitem ProjItem1,A3,ProjText1,#'N',#0
                lea      ProjItem3,A3        ;in menu item structures.
                passitem ProjItem2,A3,ProjText2,#'O',#9
                lea      ProjItem4,A3
                passitem ProjItem3,A3,ProjText3,#'S',#18
                lea      ProjItem5,A3
                passitem ProjItem4,A3,ProjText4,#'A',#27
                lea      ProjItem6,A3
                passitem ProjItem5,A3,ProjText5,#'P',#36
                lea      ProjItem7,A3
                passitem ProjItem6,A3,ProjText6,#'R',#45
                passitem ProjItem7,#0,ProjText7,#'Q',#54

                lea      ProjMenu,A0         ;Finally, must initialize the
                lea      EditMenu,A1         ;menu structure itself.
                move.l   A1,mu_NextMenu(A0)  ;pointer to next menu in list
                move     #0,mu_LeftEdge(A0)  ;place for title in menu strip
                move     #0,mu_TopEdge(A0)   ;ignored
                move     #0,mu_Height(A0)    ;ignored
                move     #100,mu_Width(A0)
                move     #MENUENABLED,mu_Flags(A0) ;menu is enabled
                lea      ProjName,A1
                move.l   A1,mu_MenuName(A0)
                lea      ProjItem,A1
                move.l   A1,mu_FirstItem(A0) ;head of menu item list

                passtext EditText1,Edit1     ;Now, repeat process for
                passtext EditText2,Edit2     ;the second menu.
                passtext EditText3,Edit3
                passtext EditText4,Edit4
                passtext EditText5,Edit5

                lea      EditItem2,A3
                passitem EditItem1,A3,EditText1,#'Z',#0
                lea      EditItem3,A3
                passitem EditItem2,A3,EditText2,#'X',#9
                lea      EditItem4,A3
                passitem EditItem3,A3,EditText3,#'C',#18
                lea      EditItem5,A3
                passitem EditItem4,A3,EditText4,#'V',#27
                passitem EditItem5,#0,EditText5,#'D',#36

                lea      EditMenu,A0
                move.l   #0,mu_NextMenu(A0)  ;end of the list
                move     #101,mu_LeftEdge(A0)
                move     #0,mu_TopEdge(A0)
                move     #75,mu_Width(A0)
                move     #0,mu_Height(A0)
                move     #MENUENABLED,mu_Flags(A0)
                lea      EditName,A1
                move.l   A1,mu_MenuName(A0)
                lea      EditItem1,A1
                move.l   A1,mu_FirstItem(A0)

                move.l   IntBase,A6
                move.l   WindowPtr,A0        ;window in question
                lea      ProjMenu,A1         ;first menu in strip
                callsys  SetMenuStrip        ;attach menu strip to window

;-------------- Initialize message ports for console ------------------
                lea      WritePort,A3        ;storage for pointer to write port
                move.l   #0,A5               ;unnamed ports - first in list
                jsr      CreatePort          ;initialize the port

                move.l   WritePort,A3        ;write port pointer
                lea      WriteMsg,A5         ;storage for pointer to IO block
                jsr      CreateStdIO         ;initialize IO block

                lea      ReadPort,A3         ;Repeat for read port.
                lea      ReadName,A5         ;has name - not first in list
                jsr      CreatePort

                move.l   ReadPort,A3
                lea      ReadMsg,A5
                jsr      CreateStdIO

;-------------- Open and attach the console device --------------------
                move.l   WriteMsg,A3         ;output IO request block
                move.l   ReadMsg,A5          ;input IO request block
```

```
        move.l    WindowPtr,A4          ;window for this console
        jsr       OpenConsole
        cmp       #0,D0
        beq       GoOn
        rts                             ;unsuccessful opening ends program

;------------- Identify signal bits -----------------------------------
GoOn    move.l    WindowPtr,A0
        move.l    wd_UserPort(A0),A0    ;message port for Intuition
        move.b    MP_SIGBIT(A0),D0      ;Intuition signal bit
        lea       IntSigBit,A0
        move.b    D0,(A0)               ;save it
        move.l    ReadPort,A0
        move.b    MP_SIGBIT(A0),D0      ;console signal bit
        lea       ConSigBit,A0
        move.b    D0,(A0)               ;save it

;-------------- Queue up an initial read request ---------------------
        move.l    ReadMsg,A1            ;console IO request block
        lea       letter,A4             ;place to put character read
        jsr       QueueRead             ;queue up a message

;------------ Wait for Intuition or console event --------------------
Event   clr.l     D1
        move.b    IntSigBit,D1
        clr.l     D0
        bset.l    D1,D0                 ;sys will look for Intuition event
        clr.l     D1
        move.b    ConSigBit,D1
        bset.l    D1,D0                 ;system looks for console evt, too
        move.l    _AbsExecBase,A6
        callsys   Wait                  ;wait for event to occur

        clr.l     D1                    ;Note - now a bit in D0 is set
        move.b    IntSigBit,D2          ;to correspond to signal causing
        bset.l    D2,D1                 ;event.
        cmp.l     D1,D0                 ;Intuition event?
        beq       IntuitionEvent

        clr.l     D1
        move.b    ConSigBit,D2
        bset.l    D2,D1
        cmp.l     D1,D0                 ;console event?
        beq       ConsoleEvent

        bra       Event                 ;fail-safe trap-should never get here

;------------- Handle Intuition events -------------------------------
IntuitionEvent
        move.l    WindowPtr,A0
        move.l    wd_UserPort(A0),A0    ;Intuition's message port
        move.l    _AbsExecBase,A6
        callsys   GetMsg                ;retrieve the input message
        beq       Event                 ;no message present

        move.l    D0,A1                 ;GetMsg returns address of message in D0
        move.l    im_Class(A1),D0       ;type of event
        cmp       #CLOSEWINDOW,D0       ;was window close box clicked?
        beq       CloseAndQuit

        cmp       #MENUPICK,D0          ;menu choice made?
        beq       MenuEvent

DoneWithEvent
        move.l    _AbsExecBase,A6
        callsys   ReplyMsg              ;remove message so it can be reused
        bra       Event

MenuEvent
        move      im_Code(A1),D0        ;menu & menu item number
        beq       DoneWithEvent         ;user backed out before chosing

        move      D0,D1                 ;save the code
        and       #%0000000000011111,D0 ;get menu number
        cmp       #0,D0                 ;project menu?
        bne       DoneWithEvent         ;Project menu is the only one
                                        ;trapped by this program!!!!

        lsr       #5,D1
        and       #%0000000000111111,D0 ;get menu item number
        cmp       #6,D1                 ;Quit selected?
        bne       DoneWithEvent         ;Quit is the only option
                                        ;implemented by this program!!!!!

CloseAndQuit
        move.l    ReadMsg,A1
        ABORTIO                         ;remove last event from queue

        move.l    ReadMsg,A1
        move.l    _AbsExecBase,A6
        callsys   CloseDevice           ;close the console

        move.l    WindowPtr,A0
        move.l    IntBase,A6
        callsys   CloseWindow           ;close the window
```

(continued on next page)

MAC AND AMIGA

Listing Three *(Listing continued, text begins on page 40.)*

```
                 move.l    ScreenPtr,A0
                 move.l    IntBase,A6
                 callsys   CloseScreen         ;close the custom screen

                 rts                           ;return to DOS

;----------- Handle console events ----------------------------------
        ConsoleEvent
                 move.l    ReadMsg,A0
                 move.l    _AbsExecBase,A6
                 callsys   GetMsg              ;retrieve the message
                 move.l    WriteMsg,A1         ;output IO request block
                 lea       letter,A4           ;place where character is stored
                 jsr       ConPutChar          ;display the character
                 move.b    letter,D0
                 cmp       #$D,D0              ;was character a <cr>?
                 bne       MoreLetters
                 move.b    #$A,(A4)            ;put line feed in letter
                 move.l    WriteMsg,A1
                 jsr       ConPutChar          ;add a line feed to the <cr>

        MoreLetters
                 move.l    ReadMsg,A1
                 move.l    DevAdd,IO_DEVICE(A1)
                 jsr       QueueRead ;go get another letter

                 bra       Event

;--------- Subroutine to load Intuition text structures ---------------
        SetText  move.b    #FrontPen,it_FrontPen(A0)  ;colors for drawing
                 move.b    #BackPen,it_BackPen(A0)
                 move.b    #0,it_DrawMode(A0)
                 move      #2,it_LeftEdge(A0)  ;posn rel to container
                 move      #1,it_TopEdge(A0)
                 move.l    #0,it_ITextFont(A0) ;use default font
                 move.l    A1,it_IText(A0)     ;pointer to the text structure
                 move.l    #0,it_NextText(A0)  ;no link to other txt structs
                 rts

;---------- Subroutine to load menu item structures ------------------
        SetItem  move.l    A1,mi_NextItem(A0)  ;pointer to next item in list
                 move      #2,mi_LeftEdge(A0)  ;posn rel to container
                 move      D1,mi_TopEdge(A0)
                 move      #100,mi_Width(A0)
                 move      #9,mi_Height(A0)
                 move      #ITEMTEXT+COMMSEQ+ITEMENABLED+HIGHCOMP,mi_Flags(A0)
                 move.l    #0,mi_MutualExclude(A0)      ;no mutually exclusive items
                 move.l    A2,mi_ItemFill(A0)  ;pointer to text structure
                 move.b    D0,mi_Command(A0)   ;keyboard equivalent
                 move.l    #0,mi_SubItem(A0)   ;no subitems
                 move      #0,mi_NextSelect(A0) ;no associated items
                 rts

;------------ Create a message port ----------------------------------
;NOTE - this subroutine is an assembly language version of the C source
;code provided in the Amiga ROM kernel manual. It needs error trapping
;after the system calls to be complete.
;Load address of pointer to message port structure in A3.
;Load pointer to name for message port in A5.
```

(continued on page 79)

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Listing Three *(Listing continued, text begins on page 40.)*

```
CreatePort
                move      #-1,D0               ;no preference for signal bit
                move.l    _AbsExecBase,A6
                callsys   AllocSignal          ;allocate a signal bit for port

                move.b    D0,D7                ;save signal bit
                clr.l     D1
                bset.l    #16,D1               ;(clear)
                bset.l    #0,D1                ;(public)  requirements
                move      #MP_SIZE,D0          ;number of bytes needed
                move.l    _AbsExecBase,A6
                callsys   AllocMem             ;memory for message port structure

                move.l    D0,(A3)              ;save pointer to message port
                move.l    D0,A4
                move.l    #0,D0
                move.l    _AbsExecBase,A6
                callsys   FindTask  ;initialize task control block

                move.l    A5,LN_NAME(A4)       ;port's name
                move.b    #0,LN_PRI(A4)        ;port's priority
                move.b    #NT_MSGPORT,LN_TYPE(A0)  ;type of port
                move.b    #PA_SIGNAL,MP_FLAGS(A0)
                move.b    D7,MP_SIGBIT(A4)     ;signal bit
                move.l    D0,MP_SIGTASK(A4)    ;address of task ctrl block

                cmp.l     #0,A5                ;is name specified?
                beq       Port2                ;head of list of ports
                move.l    A4,A1
                move.l    _AbsExecBase,A6
                callsys   AddPort              ;add this port to list
                rts

        Port2   lea       MP_MSGLIST(A4),A0
                NEWLIST   A0                   ;initialize a new list of ports
                rts

;--------------- Create a standard IO request structure ---------------
;NOTE - this subroutine is an assembly language version of the C source
;code provided in the Amiga ROM kernel manual. It needs error trapping
;after the system calls to be complete.
;Load pointer to message port in A3.
;Load address of pointer for standard IO structure in A5.

CreateStdIO
                clr.l     D1
                bset.l    #16,D1
                bset.l    #0,D1
                move.l    #IOSTD_SIZE,D0
                move.l    _AbsExecBase,A6
                callsys   AllocMem             ;space for IO request block

                move.l    D0,(A5)              ;save the pointer
                move.l    D0,A0
                move.b    #NT_MESSAGE,LN_TYPE(A0)  ;type of structure
                move.b    #0,LN_PRI(A0)        ;priority
                move.l    A3,MN_REPLYPORT(A0)  ;address of message port
                rts

;-------- Subroutine to open the console device --------------------
;NOTE - this subroutine is an assembly language version of the C source
;code provided in the Amiga ROM kernel manual.
;Load pointer to WriteMsg in A3.
;Load pointer to ReadMsg in A5.
;Load pointer to Window in A4.

        OpenConsole
                move.l    A4,IO_DATA(A3)       ;pointer to window record
                move      #nw_SIZE,IO_LENGTH(A3)        ;size of window record
                lea       ConDev,A0 ;name of device
                move.l    #0,D0
                move.l    A3,A1
                move.l    #0,D1
                move.l    _AbsExecBase,A6
                callsys   OpenDevice

                move.l    IO_DEVICE(A3),IO_DEVICE(A5) ;save device pointers
                move.l    IO_DEVICE(A3),DevAdd
                move.l    IO_UNIT(A3),IO_UNIT(A5)
                rts

;------ Subroutine to queue up a read request to the console -----------
;NOTE - this subroutine is an assembly language version of the C source
;code provided in the Amiga ROM kernel manual.
;Load pointer to read message in A1.
;Load pointer to storage space for character in A4.

        QueueRead
                move      #CMD_READ,IO_COMMAND(A1) ;type of operation
                move.l    A4,IO_DATA(A1)       ;where data should be placed
                move.l    #1,IO_LENGTH(A1)     ;number of bytes to read
                move.l    _AbsExecBase,A6
                callsys   SendIO
                rts
```

(continued on next page)

Listing Three

(Listing continued, text begins on page 40.)


```
;-------- Subroutine to print a single character in a console window ----
;NOTE - this subroutine is an assembly language version of the C source
;code provided in the Amiga ROM kernel manual.
;Load pointer to write message in A1
;Load pointer to character to be printed in A4.

        ConPutChar
                move      #CMD_WRITE,IO_COMMAND(A1) ;type of operation
                move.l    A4,IO_DATA(A1)      ;where data will come from
                move.l    #1,IO_LENGTH(A1)    ;number of bytes to output
                move.l    _AbsExecBase,A6
                callsys   DoIO
                rts

**************************** Data Structures ******************************
        DevAdd              ds.l      1
        TheScreen ds.b      ns_SIZEOF
        TheWindow ds.b      nw_SIZE
        IntBase             ds.l      1
        IntName             dc.b      'intuition.library',0
        WindowPtr ds.l      1
        WindowTitle         dc.b      'Text Window',0
        ScreenPtr ds.l      1
        ScreenTitle         dc.b      'Dr. Dobbs Journal',0
        ConDev              dc.b      'console.device',0,0
        ;NOTE - extra 0 included to keep addresses even

        ProjMenu  ds.b      mu_SIZEOF
        ProjName  dc.b      'Project',0
        Proj1               dc.b      'New',0
        ProjText1 ds.b      it_SIZEOF
        ProjItem1 ds.b      mi_SIZEOF

        Proj2               dc.b      'Open',0,0
        ProjText2 ds.b      it_SIZEOF
        ProjItem2 ds.b      mi_SIZEOF

        Proj3               dc.b      'Save',0,0
        ProjText3 ds.b      it_SIZEOF
        ProjItem3 ds.b      mi_SIZEOF

        Proj4               dc.b      'Save As',0
        ProjText4 ds.b      it_SIZEOF
        ProjItem4 ds.b      mi_SIZEOF

        Proj5               dc.b      'Print',0
        ProjText5 ds.b      it_SIZEOF
        ProjItem5 ds.b      mi_SIZEOF

        Proj6               dc.b      'Print As',0,0
        ProjText6 ds.b      it_SIZEOF
        ProjItem6 ds.b      mi_SIZEOF

        Proj7               dc.b      'Quit',0,0
        ProjText7 ds.b      it_SIZEOF
        ProjItem7 ds.b      mi_SIZEOF

        EditMenu  ds.b      mu_SIZEOF
        EditName  dc.b      'Edit',0,0
        Edit1               dc.b      'Undo',0,0
        EditText1 ds.b      it_SIZEOF
        EditItem1 ds.b      mi_SIZEOF

        Edit2               dc.b      'Cut',0
        EditText2 ds.b      it_SIZEOF
        EditItem2 ds.b      mi_SIZEOF

        Edit3               dc.b      'Copy',0,0
        EditText3 ds.b      it_SIZEOF
        EditItem3 ds.b      mi_SIZEOF

        Edit4               dc.b      'Paste',0
        EditText4 ds.b      it_SIZEOF
        EditItem4 ds.b      mi_SIZEOF

        Edit5               dc.b      'Erase',0
        EditText5 ds.b      it_SIZEOF
        EditItem5 ds.b      mi_SIZEOF

        ReadPort  ds.l      1
        ReadMsg             ds.l      1
        ReadName  dc.b      'Read',0,0
        WritePort ds.l      1
        WriteMsg  ds.l      1
        IntSigBit ds.b      1
        ConSigBit ds.b      1
        letter              ds.b      1
```

End Listings

Listing One *(Text in December)*

```
/* A32000.C - Series 32000 assembler
   850903 rr fix addr ext, scaled index, acp, cxp 0.10
   850902 rr add scaled index logic 0.09
   850828 rr fix enter, setcfg, lpr/spr, index 0.08
   850809 rr add equate logic 0.07
   850730 rr add binary search in lookup 0.06
   850729 rr symbol table mods, reglist 0.05

Still need:
   --- register names for lpr/spr
   --- linkable modules

Note: While 68000 is hilo (high-bytes at lower memory
   addresses), 32000 is lohi (low-bytes at lower memory
   addresses, like the Z80).

   This is a 3-pass assembler; 3 passes to make
   sure that relative branches are computed correctly. */

#define EOF -1

#define SYMSIZ 1024        /* symbol table size */

char inpbuf[ 256 ];        /* input buffer */
int inpcnt, inpptr;        /* input counter, pointer */

char word_buffer[ 128 ];       /* buff for current word */
char ambig_buffer[ 128 ];      /* ambiguous refs here */

char listline[ 81 ];       /* line of listing output */
int listop, listcp;        /* pointers for list output */

int paren = 0;             /* used in gchar() */
int brack = 0;
int quote = 0;

int iwparen = 0;           /* used in inword() */

int errors = 0;            /* count of errors */

char *word;                /* pointer to current word */
char *ambig[ 10 ];         /* filled in by match */
int ambcnt = 0;            /* count of pointers in ambig[] */

int pass;                  /* pass = 1, 2 or 3 */
long int asmadr, codadr; /* assembly addr, code addr */
char filename[ 30 ];

int fasm, fobj;            /* file numbers */

char objbuf[ 64 ];         /* object byte buffer */
long int objadr;           /* addr of first byte of buf */
int objcnt = 0;            /* count of bytes in buffer */

struct {                   /* Symbol table */
   char *snam;             /* symbol name */
   long int sval;          /* value */
} symbol[ SYMSIZ ];

int symcnt;                /* count of symbols */

char hexchr[ 17 ] = "0123456789abcdef";

/* --- 32000 opcodes --- */

/* Note: Shortest form of opcode must be listed first. */

#define MAXOP 149

/* the opcode binary value should be a string of bits,
   e.g. 0111xxxxx000b the opcode opopt character is used
   to specify special operands, etc. */

/* opopts used here for the 32000 are:
   blank      nothing special
   a    gen
   b    gen short
   c    gen gen
   d    00000 short
   e    gen gen reg
   f    reglist save/enter
```

```
   g     reglist restore/exit
   h     00000 gen (sfsr)
   i     inss/exts
   j     movs/skps/cmps
   k     setcfg
   l     procreg, gen for lpr/spr
   m     index (operand order)
   n     ret/rett - postbyte
   o     movm
   p     cxp (disp after instruction) */

struct {
   char *onam;  /* opcode name */
   int ocnt;    /* operand count, negative if PC-rel */
   char *obin;  /* opcode binary value */
   char oopt;   /* opcode opopt char */
} opcode[ MAXOP ] = {

/* Format 1 ops (16) */

   "bsr",       -1,  "02h",    ' ',
   "ret",       1,   "12h",    'n',
   "cxp",       1,   "22h",    'p',
   "rxp",       1,   "32h",    'n',
   "rett",      1,   "42h",    'n',
   "reti",      0,   "52h",    ' ',
   "save",      1,   "62h",    'f',
   "restore",   1,   "72h",    'g',
   "enter",     2,   "82h",    'f',
   "exit",      1,   "92h",    'g',
   "nop",       0,   "0a2h",   ' ',
   "wait",      0,   "0b2h",   ' ',
   "dia",       0,   "0c2h",   ' ',
   "flag",      0,   "0d2h",   ' ',
   "svc",       0,   "0e2h",   ' ',
   "bpt",       0,   "0f2h",   ' ',

/* Conditional branches (15) */

   "beq",       -1,   "0ah",    'b',
   "bne",       -1,   "1ah",    'b',
   "bcs",       -1,   "2ah",    'b',
   "bcc",       -1,   "3ah",    'b',
   "bhi",       -1,   "4ah",    'b',
   "bls",       -1,   "5ah",    'b',
   "bgt",       -1,   "6ah",    'b',
   "ble",       -1,   "7ah",    'b',
   "bfs",       -1,   "8ah",    'b',
   "bfc",       -1,   "9ah",    'b',
   "blo",       -1,   "0aah",   'b',
   "bhs",       -1,   "0bah",   'b',
   "blt",       -1,   "0cah",   'b',
   "bge",       -1,   "0dah",   'b',
   "br",        -1,   "0eah",   'b',

/* Format 2 ops (7) */

   "addq?",     2,    "xxxxxxxxx00011iib",    'e',
   "cmpq?",     2,    "xxxxxxxxx00111iib",    'e',
   "spr?",      2,    "xxxxxxxxx01011iib",    'l',
   "lpr?",      2,    "xxxxxxxxx11011iib",    'l',

   "seq?",      1,    "xxxxx000001111iib",    'a',
   "sne?",      1,    "xxxxx000101111iib",    'a',
   "scs?",      1,    "xxxxx001001111iib",    'a',
   "scc?",      1,    "xxxxx001101111iib",    'a',
   "shi?",      1,    "xxxxx010001111iib",    'a',
   "sls?",      1,    "xxxxx010101111iib",    'a',
   "sgt?",      1,    "xxxxx011001111iib",    'a',
   "sle?",      1,    "xxxxx011101111iib",    'a',
   "sfs?",      1,    "xxxxx100001111iib",    'a',
   "sfc?",      1,    "xxxxx100101111iib",    'a',
   "slo?",      1,    "xxxxx101001111iib",    'a',
   "shs?",      1,    "xxxxx101101111iib",    'a',
   "slt?",      1,    "xxxxx110001111iib",    'a',
   "sge?",      1,    "xxxxx110101111iib",    'a',
   "st?",       1,    "xxxxx111001111iib",    'a',
   "sf?",       1,    "xxxxx111101111iib",    'a',

/* The acb instruction 3rd operand is a relative jump */
```

(continued on page 85)

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Listing One *(Listing continued)*

```
   "acb?",      -3,   "xxxxxxxxx10011iib",   'e',
   "movq?",      2,   "xxxxxxxxx10111iib",   'e',

/* Format 3 instructions (7) */

   "cxpd",       1,   "xxxxx00001111111b",   'a',
   "bicpsr?",    1,   "xxxxx001011111iib",   'a',
   "jump",       1,   "xxxxx01001111111b",   'a',
   "bispsr?",    1,   "xxxxx011011111iib",   'a',
   "adjsp?",     1,   "xxxxx101011111iib",   'a',
   "jsr",        1,   "xxxxx11001111111b",   'a',
   "case?",      1,   "xxxxx111011111iib",   'a',

/* Format 11 ops (16) -
   moved here so wildcards won't interfere */

   "addf",       2,   "xxxxxxxxxx00000110111110b",   'c',
   "addl",       2,   "xxxxxxxxxx00000010111110b",   'c',
   "movf",       2,   "xxxxxxxxxx00010110111110b",   'c',
   "movl",       2,   "xxxxxxxxxx00010010111110b",   'c',
   "cmpf",       2,   "xxxxxxxxxx00100110111110b",   'c',
   "cmpl",       2,   "xxxxxxxxxx00100010111110b",   'c',
   "subf",       2,   "xxxxxxxxxx01000110111110b",   'c',
   "subl",       2,   "xxxxxxxxxx01000010111110b",   'c',
   "negf",       2,   "xxxxxxxxxx01010110111110b",   'c',
   "negl",       2,   "xxxxxxxxxx01010010111110b",   'c',
   "divf",       2,   "xxxxxxxxxx10000110111110b",   'c',
   "divl",       2,   "xxxxxxxxxx10000010111110b",   'c',
   "mulf",       2,   "xxxxxxxxxx11000110111110b",   'c',
   "mull",       2,   "xxxxxxxxxx11000010111110b",   'c',
   "absf",       2,   "xxxxxxxxxx11010110111110b",   'c',
   "absl",       2,   "xxxxxxxxxx11010010111110b",   'c',

/* Format 4 instructions (12) */

   "add?",       2,   "xxxxxxxxxx0000iib",   'c',
   "cmp?",       2,   "xxxxxxxxxx0001iib",   'c',
   "bic?",       2,   "xxxxxxxxxx0010iib",   'c',
   "addc?",      2,   "xxxxxxxxxx0100iib",   'c',
   "mov?",       2,   "xxxxxxxxxx0101iib",   'c',
   "or?",        2,   "xxxxxxxxxx0110iib",   'c',
   "sub?",       2,   "xxxxxxxxxx1000iib",   'c',
   "addr",       2,   "xxxxxxxxxx100111b",   'c',
   "lxpd",       2,   "xxxxxxxxxx100111b",   'c',
   "and?",       2,   "xxxxxxxxxx1010iib",   'c',
   "subc?",      2,   "xxxxxxxxxx1100iib",   'c',
   "tbit?",      2,   "xxxxxxxxxx1101iib",   'c',
   "xor?",       2,   "xxxxxxxxxx1110iib",   'c',

/* Format 5 instructions (4) */

   "movst",      1,   "00000xxx100000ii00001110b",   'j',
   "movs?",      1,   "00000xxx000000ii00001110b",   'j',
   "cmpst",      1,   "00000xxx100001ii00001110b",   'j',
   "cmps?",      1,   "00000xxx000001ii00001110b",   'j',
   "skpst",      1,   "00000xxx100011ii00001110b",   'j',
   "skps?",      1,   "00000xxx000011ii00001110b",   'j',

   "setcfg",     1,   "00000xxxx000101100001110b",   'k',

/* Format 6 ops (14) */

   "rot?",       2,   "xxxxxxxxxx0000ii01001110b",   'c',
   "ash?",       2,   "xxxxxxxxxx0001ii01001110b",   'c',
   "cbit?",      2,   "xxxxxxxxxx0010ii01001110b",   'c',
   "cbiti?",     2,   "xxxxxxxxxx0011ii01001110b",   'c',
   "lsh?",       2,   "xxxxxxxxxx0101ii01001110b",   'c',
   "sbit?",      2,   "xxxxxxxxxx0110ii01001110b",   'c',
   "sbiti?",     2,   "xxxxxxxxxx0111ii01001110b",   'c',
   "neg?",       2,   "xxxxxxxxxx1000ii01001110b",   'c',
   "not?",       2,   "xxxxxxxxxx1001ii01001110b",   'c',
   "subp?",      2,   "xxxxxxxxxx1011ii01001110b",   'c',
   "abs?",       2,   "xxxxxxxxxx1100ii01001110b",   'c',
   "com?",       2,   "xxxxxxxxxx1101ii01001110b",   'c',
   "ibit?",      2,   "xxxxxxxxxx1110ii01001110b",   'c',
   "addp?",      2,   "xxxxxxxxxx1111ii01001110b",   'c',

/* Format 7 ops (15) */

   "movm?",      3,   "xxxxxxxxxx0000ii11001110b",   'o',
   "cmpm?",      2,   "xxxxxxxxxx0001ii11001110b",   'c',
   "inss?",      4,   "xxxxxxxxxx0010ii11001110b",   'i',
   "exts?",      4,   "xxxxxxxxxx0011ii11001110b",   'i',
   "movxbw?",    2,   "xxxxxxxxxx0100ii11001110b",   'c',
   "movzbw?",    2,   "xxxxxxxxxx0101ii11001110b",   'c',
   "movz?d",     2,   "xxxxxxxxxx0110ii11001110b",   'c',
   "movx?d",     2,   "xxxxxxxxxx0111ii11001110b",   'c',
   "mul?",       2,   "xxxxxxxxxx1000ii11001110b",   'c',
   "mei?",       2,   "xxxxxxxxxx1001ii11001110b",   'c',
   "dei?",       2,   "xxxxxxxxxx1011ii11001110b",   'c',
   "quo?",       2,   "xxxxxxxxxx1100ii11001110b",   'c',
   "rem?",       2,   "xxxxxxxxxx1101ii11001110b",   'c',
   "mod?",       2,   "xxxxxxxxxx1110ii11001110b",   'c',
   "div?",       2,   "xxxxxxxxxx1111ii11001110b",   'c',

/* Format 8 ops (8) */

   "ext?",       4,   "xxxxxxxxxxxxx0ii00101110b",   'm',
   "cvtp",       3,   "xxxxxxxxxxxxx01101101110b",   'm',
   "ins?",       4,   "xxxxxxxxxxxxx0ii10101110b",   'm',
   "check?",     3,   "xxxxxxxxxxxxx0ii11101110b",   'm',
   "index?",     3,   "xxxxxxxxxxxxx1ii00101110b",   'm',
   "ffs?",       2,   "xxxxxxxxxx0001ii01101110b",   'c',
   "movsu?",     2,   "xxxxxxxxxx0011ii10101110b",   'c',
   "movus?",     2,   "xxxxxxxxxx0111ii10101110b",   'c',

/* Format 9 ops (12) */

   "movlf",      2,   "xxxxxxxxxx0101ii00111110b",   'c',
   "movfl",      2,   "xxxxxxxxxx0111ii00111110b",   'c',
   "mov?f",      2,   "xxxxxxxxxx0001ii00111110b",   'c',
   "mov?l",      2,   "xxxxxxxxxx0000ii00111110b",   'c',
   "lfsr",       1,   "xxxxx000000011100111110b",   'a',
   "sfsr",       1,   "00000xxxxx11011100111110b",   'h',
   "roundf?",    2,   "xxxxxxxxxx1001ii00111110b",   'c',
   "roundl?",    2,   "xxxxxxxxxx1000ii00111110b",   'c',
   "truncf?",    2,   "xxxxxxxxxx1011ii00111110b",   'c',
   "truncl?",    2,   "xxxxxxxxxx1010ii00111110b",   'c',
   "floorf?",    2,   "xxxxxxxxxx1111ii00111110b",   'c',
   "floorl?",    2,   "xxxxxxxxxx1110ii00111110b",   'c',

/* Format 14 instructions (4) */

   "rdval",      1,   "xxxxxxxxx000001100011110b",   'a',
   "wrval",      1,   "xxxxxxxxx000011100011110b",   'a',
   "lmr",        2,   "xxxxxxxxx000101100011110b",   'e',
   "smr",        2,   "xxxxxxxxx000111100011110b",   'e'
};

   /* Address Mode Table */

#define MAXAM 42

struct {
   char *mstr;  /* mode match string */
   char *gstr;  /* output string to insert (gen) */
   int mcnt;    /* count of ambigs to be put into
               extension bytes */
   char mopt;   /* mode option */
} admode[ MAXAM ] = {

/* Scaled index modes */

   "*[r?:b]",   "11100",   1,   's',
   "*[r?:w]",   "11101",   1,   's',
   "*[r?:d]",   "11110",   1,   's',
   "*[r?:q]",   "11111",   1,   's',

/* Simple register modes */

   "r0",   "00000",   0,   ' ',   /* main registers */
   "r1",   "00001",   0,   ' ',
   "r2",   "00010",   0,   ' ',
   "r3",   "00011",   0,   ' ',
   "r4",   "00100",   0,   ' ',
   "r5",   "00101",   0,   ' ',
   "r6",   "00110",   0,   ' ',
   "r7",   "00111",   0,   ' ',

   "f0",   "00000",   0,   ' ',   /* floating point */
   "f1",   "00001",   0,   ' ',
   "f2",   "00010",   0,   ' ',
```

(continued on next page)

Listing One *(Listing continued)*

```
   "f3",    "00011",   0,    ' ',
   "f4",    "00100",   0,    ' ',
   "f5",    "00101",   0,    ' ',
   "f6",    "00110",   0,    ' ',
   "f7",    "00111",   0,    ' ',

/* Indexed addressing modes */

   "*(r0)",    "01000",   1,    ' ',   /* indexed */
   "*(r1)",    "01001",   1,    ' ',
   "*(r2)",    "01010",   1,    ' ',
   "*(r3)",    "01011",   1,    ' ',
   "*(r4)",    "01100",   1,    ' ',
   "*(r5)",    "01101",   1,    ' ',
   "*(r6)",    "01110",   1,    ' ',
   "*(r7)",    "01111",   1,    ' ',

   "*(*(fp))",  "10000",   2,    'r',   /* frame ptr */
   "*(*(sp))",  "10001",   2,    'r',   /* stack mem */
   "*(*(sb))",  "10010",   2,    'r',   /* static mem */

   "#*",        "10100",   1,    ' ',   /* immediate */
   "@*",        "10101",   1,    ' ',   /* absolute */
   "ext(*)+*",  "10110",   2,    ' ',   /* external */
   "tos",       "10111",   0,    ' ',   /* top of stack */

   "*(fp)",     "11000",   1,    ' ',   /* frame mem */
   "*(sp)",     "11001",   1,    ' ',   /* stack mem */
   "*(sb)",     "11010",   1,    ' ',   /* static mem */

   ".+*",       "11011",   1,    ' ',   /* program mem */

   "[*]",       "",   0,   'l',   /* register list */

/* catch-all */

   "*",   "",   1,   'w' /* fits no pattern */
};

/*---MAIN PROGRAM---*/

main( argc, argv )
int argc;
char *argv[];
{
   int i;

   puts( "\nA32000 v0.10" );

   if( argc < 2 ) {
      puts( "\n?No file name specified" );
      exit( 1 );
   }

   symcnt = 0;

   for( pass = 1; pass <= 3; ++pass ) {

      makename( argv[ 1 ], ".s" );
      fasm = fopen( filename, "r" );

      if( fasm == 0 ) {
         puts( "\n?Unable to open source file" );
         exit( 1 );
      }

      if( pass == 3 ) {
         makename( argv[ 1 ], ".hex" );
         fobj = fopen( filename, "w" );
         if( ! fobj ) {
            puts( "\n?No directory space" );
            exit( 1 );
         }
      }

      puts( "\nPass " );
      putchar( pass + '0' );

      asmadr = 0;
      codadr = 0;
      if( pass == 3 ) {
```

```
        objflush();
        listnl();
     }
     inpload();

     while( gword() ) {

        if( match( word, "end" )) break;

/* Each word is processed by the following nested if
   statement, which attempts to identify what it is.
   Note that any successful identification stops the
   process of the statement. */

        if( ! islabel( word ))
           if( ! ispseudo( word ))
              if( ! isopcode( word ))
                 if( ! isequate( word ))
                    error( '?', word );
     }

     fclose( fasm );

/* Sort symbols after pass 1. */

     if( pass == 1 ) sortsyms();

     if( pass == 3 )   {
        objflush();

        putc( ':', fobj );     /* write eof record */
        for( i = 0; i < 10; ++i ) putc( '0', fobj );
        putc( '\n', fobj );

        fclose( fobj );
     }
  }

  listpr();
  puts( "\n\n" );
  dumpsyms();

  if( errors )
     puts( "\n---Fix errors and reassemble---" );
}

/* Construct a filename from two strings. */

makename( p, q )
char *p, *q;
{
   char *r;
   r = &filename[ 0 ];
   while( *p ) *r++ = *p++;
   while( *q ) *r++ = *q++;
   *r = '\0';
}

/* Check to see if the word is a label, and if it is, add
   its value to the symbol table */

int islabel( w )
char *w;
{
   while( *w ) ++w;
   if( *--w != ':' ) return 0;
   *w = '\0';    /* take off the colon */

   addsymbol( word, codadr );
   return 1;
}

/* Check the word to see if it is a pseudo-op. */

int ispseudo( w )
char *w;
{
   long int getarg(), temp;

   if( match( w, "org" )) {
   asmadr = getarg();
   codadr = asmadr;
   if( pass == 3 ) objflush();
```

(continued on next page)

Listing One *(Listing continued)*

```
      return 1;
   }

   if( match( w, "db" )) {       /* Note: Allow msgs? */
      temp = getarg();           /* get argument */
      objout( temp & 0xFF );     /* output byte */
      return 1;
   }

   if( match( w, "dw" )) {
      temp = getarg();           /* get argument */
      objout( temp & 0xFF );     /* output lsb */
      objout(( temp >> 8 ) & 0xFF );     /* output msb */
      return 1;
   }

   if( match( w, "dd" )) {
      temp = getarg();           /* get argument */
      objout( temp & 0xFF );     /* output lsb */
      objout(( temp >> 8 ) & 0xFF );
      objout(( temp >> 16 ) & 0xFF );
      objout(( temp >> 24 ) & 0xFF );    /* output msb */
      return 1;
   }

   if( match( w, "even" ) && ( codadr & 1 )) {
      objout( 0 ); /* send 1 byte to go to word bndry */
      return 1;
   }

   return 0;
}

/* Check to see if the word is an opcode, and if it is,
   get any operands required and generate code. */

int isopcode( w )
char *w;
{
   long int value(), bitbin(), decbin(), o, ocodadr;
   char opbuf[ 33 ], bytbuf[ 33 ], extbuf[ 128 ];
   char opopt, modopt, opsiz, opcnt;
   int i, j, k, l;
   char *p, *q, *cpystr(), *regbits();

   /* postbytes & scaled indexes */
   int opexbt[ 4 ], opexct;

   int adexct, adexln[ 8 ];
   char *adexpt[ 8 ], *eoadex; /* addressing extensions */

   ocodadr = codadr;    /* save addr of begin of instr */

   opexct = 0;          /* no postbytes as yet */
   adexct = 0;          /* no extensions as yet */
   eoadex = &extbuf[ 0 ]; /* point to begin of extbuf */

   for( i = 0; i < MAXOP; ++i )
      if( match( w, opcode[ i ].onam )) {

      opopt = opcode[ i ].oopt;

      if( opopt == 'x' ) {
         error( 'x', w ); /* unimplemented instruction */
         return 1;
      }

      p = cpystr( opcode[ i ].obin, &opbuf[ 0 ] );

/* see if length modifier */

      if( ambcnt > 0 ) {
         p = &opbuf[ 0 ];
         opsiz = *ambig[ 0 ];

         while( *p && *p != 'i' ) ++p;

         if( ! *p ) error( 'l', w );
         else {
         switch( opsiz ) {

            case 'b' : *p++ = '0';
               *p++ = '0';
               break;

            case 'w' : *p++ = '0';
               *p++ = '1';
               break;

            case 'd' : *p++ = '1';
               *p++ = '1';
            }
         }
      }

/* now parse operands */

/* get count of operands.
   Take abs value (neg = PC-relative) */

      opcnt = opcode[ i ].ocnt;
      if( opcnt < 0 ) opcnt = 0 - opcnt;

      p = &opbuf[ 0 ];  /* modified parts start at beg. */

      for( j = 0; j < opcnt; ++j ) {
         gword();       /* get operand */

/* find addr mode */

         k = 0;
         while(( k < MAXAM )
            && ! match( word, admode[ k ].mstr )) ++k;

         modopt = admode[ k ].mopt;

/* move bit string into place */

         q = admode[ k ].gstr;

/* if opopt h, sfsr, skip 5 bits */

         if( opopt == 'h' ) p += 5;

/* for most opopts, move the bits in */

         if(( opopt == ' ' )
            || ( opopt == 'a' )
            || ( opopt == 'c' )
            || ( opopt == 'e' && j == 1 )
            || ( opopt == 'h' )
            || ( opopt == 'i' && j < 2 )
            || ( opopt == 'l' && j == 1 )
            || ( opopt == 'm' && j > 0 && j < 3 )
            || ( opopt == 'o' && j < 2 ))
            while( *q ) *p++ = *q++;

/* Double the effort for scaled index mode.  create an
   extension postbyte opexbt[] with basemode as upper
   5 bits, reg as lower 3 bits. */

         if( admode[ k ].mopt == 's' ) {
            l = ( *ambig[ 1 ] ) & 7;
            q = cpystr( ambig[ 0 ], &bytbuf[ 0 ] );

/* find basemode */

            k = 0;
            while(( k < MAXAM )
               && ! match( &bytbuf[ 0 ],
               admode[ k ].mstr )) ++k;

            modopt = admode[ k ].mopt;

/* move bit string into postbyte.  use bitbin, because
   value() destroys ambig[] array which we still need. */

            q = cpystr( admode[ k ].gstr,
               &bytbuf[ 0 ] );
            --q;                 /* back up to null */
            *q++ = '0' + (( l >> 2 ) & 1 );
            *q++ = '0' + (( l >> 1 ) & 1 );
```

```
            *q++ = '0' + ( l & 1 );
            *q = '\0';

            opexbt[ opexct++ ] = bitbin( &bytbuf[ 0 ] );
            q = admode[ k ].gstr;
         }

/* funny handling of reg: index operation (opopt 'm') */

         if( opopt == 'm' && j == 0 ) {
            p = &opbuf[ 10 ];    /* off to reg */
            q += 2;              /* skip 0 bits */
            while( *q ) *p++ = *q++;
            p = &opbuf[ 0 ];     /* reset */
         }

/* move ambigs into extension bytes. set length to
   variable (0). For some addressing modes, the
   extensions go in in reverse order */

         if( modopt == 'r' )
            for( l = admode[ k ].mcnt - 1; l >= 0;
               --l ) {
               adexpt[ adexct ] = eoadex;
               adexln[ adexct ] = 0;
               ++adexct;
               eoadex = cpystr( ambig[ l ], \
                  eoadex );
         } else for( l = 0; l < admode[ k ].mcnt; ++l ) {
               adexpt[ adexct ] = eoadex;
               adexln[ adexct ] = 0;
               ++adexct;
               eoadex = cpystr( ambig[ l ], \
                  eoadex );
         }

/* special logic for register list for "enter", "save",
   "restore", "exit" */

         if(( j == 0 && opopt == 'f' ) || opopt == 'g' ) {
            adexpt[ adexct ] = eoadex;
            adexln[ adexct ] = 1;
            ++adexct;
            eoadex = regbits( word, eoadex, opopt );
         }

/* shorten extension to 1 byte for enter, return */

         if(( j == 1 && opopt == 'f' ) || opopt == 'n' ) {
            if( adexct > 0 ) adexln[ adexct - 1 ] = 1;
               else error( 'e', w );
         }

/* opopts 'e' or 'd': immed data becomes 4 bit value */

         if(( j == 0 && opopt == 'e' ) || opopt == 'd' ) {
            if( ! adexct ) error( 'e', w );
               else {
               l = value( adexpt[ --adexct ] );
               p = &opbuf[ 5 ];
               *p++ = '0' + (( l >> 3 ) & 1 );
               *p++ = '0' + (( l >> 2 ) & 1 );
               *p++ = '0' + (( l >> 1 ) & 1 );
               *p = '0' + ( l & 1 );
               p = &opbuf[ 0 ];
            }
         }

/* opopt 'i': combine last two ambigs into one postbyte.
   Put it in bytbuf and set length to 1 */

         if( opopt == 'i' && j == 3 ) {
            if( adexct < 2 ) error( 'e', w );
            else {
               l = ( value( adexpt[ --adexct ] ) - 1 )
                  & 31;
               l += ( value( adexpt[ --adexct ] )
                  & 7 ) << 5;
               bytbuf[ 0 ] = '0' +
                  (( l / 100 ) % 10 );
               bytbuf[ 1 ] = '0' +
                  (( l / 10 ) % 10 );
```

(continued on next page)

Listing One *(Listing continued)*

```
            bytbuf[ 2 ] = '0' + ( l % 10 );
            bytbuf[ 3 ] = '\0';
            adexpt[ adexct ] = &bytbuf[ 0 ];
            adexln[ adexct++ ] = 1;
         }
      }

/* opopt 'j': uwb bits for movs, cmps, skps */

      if( opopt == 'j' ) {
         p += 5;
         uwbbits( word, p );
         adexct = 0;          /* in case no paren */
      }

/* opopt 'k': config bits for setcfg */

      if( opopt == 'k' ) {
         p += 5;
         cfgbits( word, p );
      }

/* opopt 'l': operand 1 becomes 4 bit value */

      if( opopt == 'l' && j == 0 ) {
         adexct = 0;          /* unjunk extensions */
         l = -1;
         if( strcmp( word, "upsr" ) == 0 ) l = 0;
         if( strcmp( word, "fp" ) == 0 ) l = 8;
         if( strcmp( word, "sp" ) == 0 ) l = 9;
         if( strcmp( word, "sb" ) == 0 ) l = 10;
         if( strcmp( word, "psr" ) == 0 ) l = 13;
         if( strcmp( word, "intbase" ) == 0 ) l = 14;
         if( strcmp( word, "mod" ) == 0 ) l = 15;
         if( l == -1 ) error( 'p', word );
            else {
            p = &opbuf[ 5 ];
            *p++ = '0' + (( l >> 3 ) & 1 );
            *p++ = '0' + (( l >> 2 ) & 1 );
            *p++ = '0' + (( l >> 1 ) & 1 );
            *p = '0' + ( l & 1 );
            p = &opbuf[ 0 ];
            }
      }

/* odd length extension for movm, opopt 'o' */

      if( j == 2 && opopt == 'o' ) {
         if( adexct > 0 ) adexln[ --adexct ] = 1;
            else error( 'e', w );
         l = value( adexpt[ adexct ] ) - 1;
         switch( opsiz ) {
         case 'd' : l *= 4; break;
         case 'w' : l *= 2; break;
         }
         bytbuf[ 0 ] = '0' + (( l / 100 ) % 10 );
         bytbuf[ 1 ] = '0' + (( l / 10 ) % 10 );
         bytbuf[ 2 ] = '0' + ( l % 10 );
         bytbuf[ 3 ] = '\0';
         adexpt[ adexct++ ] = &bytbuf[ 0 ];
      }

   }        /* done operands */

   o = value( &opbuf[ 0 ] );

   l = strlen( opbuf );

/* Send as many opcode bytes as necessary */

   objout( o % 256 );
   if( l > 9 ) objout(( o / 256 ) % 256 );
   if( l > 17 ) objout( o / 65536 );

/* Send postbytes for scaled index mode */

   for( l = 0; l < opexct; ++l )
      objout( opexbt[ l ] );

/* Send addressing extensions.
```

```
   adexln = length of extension word in bytes if +.
   If 0, it is a variable-length signed displacement.
   If -1, indicates code-relative */

/* If opcode ocnt was negative, last address extension is
   code relative. */

      if( opcode[ i ].ocnt < 0 )
         adexln[ adexct - 1 ] = -1;

/* send extension words */

      for( j = 0; j < adexct; ++j ) {

         o = value( adexpt[ j ] );

/* if adexln[] negative, operand(s) code-relative.
   Note: on the 32000 you don't correct by adding 2 to
   codadr first */

         if( adexln[ j ] < 0 ) o -= ocodadr;

/* Compute variable-length signed displacement */

         if( adexln[ j ] <= 0 ) {
            if( o < 63 && o > -64 ) {
               o = ( o & 0x7F );
               l = 1;           /* one-byte */
            } else if( o < 8191 && o > -8192 ) {
               o = ( o & 0x3FFF ) + 0x8000;
               l = 2;
            } else {
               o = ( o & 0x3FFFFFFF )
                  + 0xC0000000;
               l = 4;
            }
         } else l = adexln[ j ];

/* address extensions are sent in lohi order */

         if( l > 3 ) objout(( o >> 24 ) & 0xFF );
         if( l > 2 ) objout(( o >> 16 ) & 0xFF );
         if( l > 1 ) objout(( o >> 8 ) & 0xFF );
         objout( o % 256 );
      }
      return 1;
   }
   return 0;
}

/* Special to create extension word for register list */

/* Regbits may look like "r0" or may look like "[r0,r2]"
   or like "[r0-r7]". */

char *regbits( src, dst, flg )
char *src, *dst, flg;
{
   int bits, reg, loreg, hireg;

   bits = 0;

   if( *src == '[' ) ++src;      /* strip parens */
      else error( '[', src );

   while( *src ) {
      if( *src++ != 'r' ) error( 'r', src );
      reg = ( *src++ ) - '0';
      bits = bits | ( 1 << reg );
      if( *src++ == '-' ) {
         loreg = reg;
         if( *src++ != 'r' ) error( 'r', src );
         hireg = ( *src++ ) - '0';
         if( hireg < loreg ) {
            reg = hireg;
            hireg = loreg;
            loreg = reg;
         }              /* swap if out of order */
         for( reg = loreg; reg <= hireg; ++reg )
            bits = bits | ( 1 << reg );
         ++src;         /* skip over the comma */
      }
      if( *src == ']' ) break;
```

(continued on next page)

Listing One *(Listing continued)*

```
   }

/* if flg = 'f', save/enter, need to swap bit
   significance. The routine above constructed it in
   reversed order in the first place, because of the
   routine below */

   if( flg == 'f' ) {
      hireg = 0;
      for( reg = 0; reg < 8; ++reg ) {
         hireg = ( hireg << 1 ) + ( bits & 1 );
         bits = ( bits >> 1 );
      }
      bits = hireg;
   }

/* now create a binary string for the extension.
   Note that bit significance becomes reversed again */

   for( reg = 0; reg < 8; ++reg ) {
      *dst++ = '0' + ( bits & 1 );
      bits = ( bits >> 1 );
   }

   *dst++ = 'b';         /* add b for binary */
   *dst++ = '\0';        /* terminate */

   return dst;
}

/* put config bits into instruction */

cfgbits( src, dst )
char *src, *dst;
{
   char b[ 4 ];

   b[ 0 ] = '0';
   b[ 1 ] = '0';
   b[ 2 ] = '0';
   b[ 3 ] = '0';

   if( *src == '[' ) ++src;      /* strip parens */
      else error( '[', src );

   while( *src ) {
      switch( *src++ ) {

      case 'c' : b[ 0 ] = '1';
            break;

      case 'm' : b[ 1 ] = '1';
            break;

      case 'f' : b[ 2 ] = '1';
            break;

      case 'i' : b[ 3 ] = '1';
      }

      if( *src++ == ']' ) break;
   }
   *dst++ = b[ 0 ];
   *dst++ = b[ 1 ];
   *dst++ = b[ 2 ];
   *dst = b[ 3 ];
}

/* put uwb bits into instruction */

uwbbits( src, dst )
char *src, *dst;
{
   char b[ 3 ];

   b[ 0 ] = '0';         /* default = forward */
   b[ 1 ] = '0';         /* default = neither */
   b[ 2 ] = '0';

   while( *src ) {
      switch( *src++ ) {

      case 'b' : b[ 2 ] = '1';  /* backward */
            break;

      case 'u' : b[ 0 ] = '1';  /* until match */
            b[ 1 ] = '1';
            break;

      case 'w' : b[ 0 ] = '0';  /* while match */
            b[ 1 ] = '1';
      }
   }
   *dst++ = b[ 0 ];
   *dst++ = b[ 1 ];
   *dst = b[ 2 ];
}

/* Check to see if the word begins an equate, and if it
   does, add the symbol to the symbol table. */

int isequate( w )
char *w;
{
   char tempword[ 128 ];
   char *q, *cpystr();
   long int l, getarg();

   q = cpystr( w, &tempword[ 0 ] );

   gword();               /* get next word */

   if( strcmp( word, "equ" ) == 0 ||
      strcmp( word, "=" ) == 0 ) {
      l = getarg();       /* get argument */

      addsymbol( &tempword[ 0 ], l );

      return 1;           /* it was an equate */
   }

   return 0;              /* we lost a word */
}

/* Get an argument value (for use above). */

long int getarg()
{
   long int value();

   gword();               /* get next word */
   return value( word );
}

/* copy string and return new ending address */

char *cpystr( src, dst )
char *src, *dst;
{
   while( *src ) *dst++ = *src++;
   *dst++ = '\0';         /* terminate copied string */
   return dst;            /* return next address */
}

/* Calculate the value of a word.  It may be a symbol, a
   constant, or a computed value (must be enclosed in
   parentheses.) */

long int value( w )
char *w;
{
   long int hexbin(), octbin(), bitbin(), decbin(), v;
   int lookup(), i, negate;

   char *q;

   char *wp[ 16 ];

   int wpcnt;

   negate = 0;

   if( *w == '-' ) {     /* Unary negation */
```

```
        negate = 1;
        ++w;
    }

    if( strcmp( w, "." ) == 0 )
        return codadr; /* . = code address */
    if( strcmp( w, ".." ) == 0 )
        return asmadr; /* .. = assembly address */

    if( isdigit( *w )) {
        if( match( w, "*h" )) v = hexbin( w );
            else if( match( w, "*q" )) v = octbin( w );
                else if( match( w, "*b" ))
                    v = bitbin( w );
                    else v = decbin( w );
    } else {

        if( *w == '(' ) {           /* --- FORMULA --- */
            ++w;                    /* skip ( */
            q = w;
            while( *q ) ++q;        /* find end of string */
            --q;
            if( *q != ')' ) error( ')', q );
                else *q = '\0';     /* zap ) */

            iwparen = 0;            /* no parens now */

            wpcnt = 0;

            while( 1 ) {            /* find beg of word */
                while( inword( *w )) ++w;

                if( ! *w ) break;

                wp[ wpcnt++ ] = w;  /* ptr to value */

                iwparen = 0;        /* find end of word */
                while( *w && ! inword( *w )) ++w;
                if( ! *w ) break;
                *w++ = '\0';        /* terminate it */

                if( wpcnt == 16 ) {
                    error( 'l', w ); /* too long */
                    break;
                }
            }

            if(( wpcnt % 2 ) == 0 ) {
                error( 'v', w );    /* must be odd */
                --wpcnt;
            }

            v = value( wp[ 0 ] );

            for( i = 1; i < wpcnt; i += 2 ) {
                if( strcmp( wp[ i ], "+" ) == 0 ) {
                    v += value( wp[ i + 1 ] );
                    goto opdone;
                }
                if( strcmp( wp[ i ], "-" ) == 0 ) {
                    v -= value( wp[ i + 1 ] );
                    goto opdone;
                }
                if( strcmp( wp[ i ], "*" ) == 0 ) {
                    v *= value( wp[ i + 1 ] );
                    goto opdone;
                }
                if( strcmp( wp[ i ], "/" ) == 0 ) {
                    v /= value( wp[ i + 1 ] );
                    goto opdone;
                }
                error( 'o', wp[ i ] );      /* unknown op */
opdone:
                i = i;              /* get around c/80 bug */
            }
        } else {                    /* --- PLAIN VALUE --- */

            i = lookup( w );        /* look up symbol */
            if( i < 0 ) return 0;   /* unknown symbol */
            v = symbol[ i ].sval;   /* return sym value */
        }
    }
```

(continued on next page)

Listing One *(Listing continued)*

```
   if( negate ) v = 0 - v;

   return v;
}

/* function for value() */

int inword( c )
char c;
{
   if( c == '(' ) ++iwparen;    /* special var for this */
   if( c == ')' ) --iwparen;    /* function */

   if( iwparen ) return 0;

   if( c == ' ' ) return 1;     /* is space */

   return 0;
}

/* --- SYMBOL TABLE LOGIC --- */

/* add new symbol to symbol table */

addsymbol( p, v )
char *p;
long int v;
{
   char *w, *cpystr(), *alloc();
   int i, lookup();

   i = lookup( p );      /* see if already known */

   if( i < 0 ) {         /* new symbol */
      i = symcnt;
      ++symcnt;          /* count a new symbol */

      symbol[ i ].snam = alloc( strlen( p ) + 1 );
      w = cpystr( p, symbol[ i ].snam );
   }

   symbol[ i ].sval = v; /* update value in table */
}

/* lookup - returns symbol number or -1 if not found */

int lookup( p )
char *p;
{
   char *w;
   int i, j, k, found;

   found = 0;            /* not found yet */

/* pass 1 - use linear search */

   if( pass == 1 ) {
      for( i = 0; i < symcnt && ! found; ++i ) {
         w = symbol[ i ].snam;
         found = ( strcmp( p, w ) == 0 );
      }
   } else {

/* passes 2 and 3 - use binary search */

      j = ( symcnt + 1 ) / 4;    /* step to use */
      i = symcnt / 2;            /* starting point */
      k = j + 1;                 /* one-step count */

      while( 1 ) {
         w = symbol[ i ].snam;
         found = strcmp( p, w );
         if( found == 0 ) {
            found = 1;
            break;
         } else if( found < 0 ) i -= j;
           else i += j;

         if( i < 0 ) i = 0;
         if( i >= symcnt ) i = symcnt - 1;

         j /= 2;                 /* halve step */

         if( j == 0 ) {
            if( k-- == 0 ) {
               found = 0;        /* not found */
               break;
            }
            j = 1;
         }
      }
   }

   if( ! found ) {
      if( pass != 1 ) error( 'u', w );
      return -1;
   }

   return i;
}

/* display error code */

error( c, p )
char c;
char *p;
{
   puts( "\n>>---> Error " );
   putchar( c );
   puts( " at " );
   puts( p );

   ++errors;
}

/* sort symbols by shell sort */

sortsyms()
{
   int jump, done, k, l;
   char *n;
   long int v;

   jump = symcnt;        /* set jmp to cnt of elements */

   while( jump > 0 ) {
      jump = jump / 2;

      while( 1 ) {
         done = 1;
         for( k = 0; k < ( symcnt - jump ); ++k ) {
            l = k + jump;
            if( strcmp( symbol[ k ].snam,
               symbol[ l ].snam ) > 0 ) {
               n = symbol[ k ].snam;
               v = symbol[ k ].sval;
               symbol[ k ].snam = symbol[ l ].snam;
               symbol[ k ].sval = symbol[ l ].sval;
               symbol[ l ].snam = n;
               symbol[ l ].sval = v;
               done = 0;
            }
         }
         if( done ) break;
      }
   }
}

/* dump symbol table */

dumpsyms()
{
   char *w;
   int i;
   long int v;

   puts( "\nSymbol and Value\n" );

   for( i = 0; i < symcnt; ++i ) {
      puts( symbol[ i ].snam );
      puts( " = " );
      v = symbol[ i ].sval;
      puthex( v >> 24, 0 );
      puthex(( v >> 16 ) & 0xFF, 0 );
```

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Listing One *(Listing continued)*

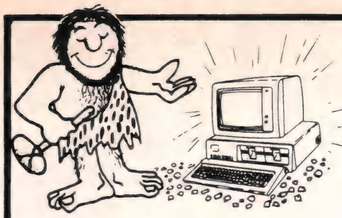
```
      puthex(( v >> 8 ) & 0xFF, 0 );
      puthex( v & 0xFF, 0 );    /* print value */
      putchar( '\n' );
   }
}

/* Match string.  If match, returns 1; else returns 0.
   Ambiguous values from the matches are saved and
   pointed to by the array of char pointers ambig[], so
   they can be checked later. */

int match( w1, w2 )
char *w1, *w2;
{
   char c;
   char *next_ambig;

   next_ambig = &ambig_buffer[ 0 ]; /* init ambig buff */
   ambcnt = 0;                      /* ambigs so far */

   while( *w1 ) {
      c = *w2++;
      if( c == '*' ) {
         ambig[ ambcnt++ ] = next_ambig;
         while( *w1 && *w1 != *w2 )
            *next_ambig++ = *w1++;
         if( ! *w1 && *w2 ) return 0;
         *next_ambig++ = '\0';  /* terminate this ambig */
      } else if( c == '?' ) {
           ambig[ ambcnt++ ] = next_ambig;
           *next_ambig++ = *w1++;      /* 1-char ambig */
           *next_ambig++ = '\0';       /* terminate it */
      } else if( c != *w1++ ) return 0;
   }
   return 1;
}

int gword()
{
   char *p, *q;
   char c, gchar();

   p = &word_buffer[ 0 ];

   c = ' ';

   while( isdelim( c )) c = gchar();

   while( ! isdelim( c )) {
      *p++ = tolower( c );
      c = gchar();
   }

   *p = '\0';   /* terminate word */

   word = &word_buffer[ 0 ];

   return 1;
}

/* is the character a delimeter? */

isdelim( c )
char c;
{
   if( paren || quote || brack )
      return 0; /* not a delim */

   if( c == ' ' || c == ',' || c == ';' || c == '\n' \
      || c == '\r' || c == '\t' )
      return 1;
   return 0;
}

/* get next char from source file */

char gchar()
{
   char c, getch();

   c = getch();          /* get char from file */
   if( c == '\'' ) quote = ! quote;
   if( c == '"' ) quote = ! quote;
   if( c == '(' ) ++paren;
   if( c == ')' ) --paren;
   if( c == '[' ) ++brack;
   if( c == ']' ) --brack;

   if( ! quote && ! paren && ! brack ) {

      while( c == ';' ) {       /* ;comment\n */
         while( getch() != '\n' ) ;
         c = getch();
      }
   }

   return c;
}

puts( p )
char *p;
{
   while( *p ) putchar( *p++ );
}

/* --- source file routines --- */

char getch()
{
   while( inpcnt == 0 ) {       /* if input buf empty, */
      listpr();          /* print listing line */
      inpload();         /* reload input buffer */
   }

   --inpcnt;
   return( inpbuf[ inpptr++ ] );
}

inpload()
{
   char c, getc();

   inpcnt = 0;
   inpptr = 0;

   while((( c = getc( fasm )) != '\n' ) && ( c != EOF )) {
      inpbuf[ inpcnt++ ] = c;
      if( listcp < 81 ) listline[ listcp++ ] = c;
   }

   inpbuf[ inpcnt++ ] = '\n';
}

/* --- listing file routines --- */

listnl()        /* list new line */
{
   int i;

   if( pass != 3 ) return;

   for( i = 0; i < 26; ++i ) listline[ i ] = ' ';
   for( i = 26; i < 81; ++i ) listline[ i ] = '\0';

   listop = 0;  /* flag to cause addr output */
   listcp = 26;
}

lbyt( b )       /* put object byte in list file */
unsigned int b;
{
   char c;

   if( pass != 3 ) return;

   c = (( b / 16 ) % 16 ) + '0';
   if( c > '9' ) c += ( 'a' - ':' );
   listline[ listop++ ] = c;

   c = ( b % 16 ) + '0';
   if( c > '9' ) c += ( 'a' - ':' );
   listline[ listop++ ] = c;
```

(continued on next page)

Listing One *(Listing continued)*

```
   if( listop > 24 ) listpr();  /* print list line */
}

listpr()         /* print list line */
{
   if( pass != 3 ) return;

   putchar( '\n' );
   puts( listline );
   listnl();
}

/* --- object file routines --- */

objout( c )
char c;
{
   asmadr++;    /* incr asmadr, codadr. DON'T incr*/
   codadr++;    /* objadr, it is addr of 1st byte */
   if( pass != 3 ) return;   /* skip if not last pass */
   objbuf[ objcnt++ ] = c;   /* put new byte in buffer */
   if( objcnt == 32 ) objflush();

   if( listop == 0 ) {           /* print address? */
      lbyt( asmadr / 16777216 );
      lbyt(( asmadr / 65536 ) % 256 );
      lbyt(( asmadr / 256 ) % 256 );
      lbyt( asmadr % 256 );
      listop = 9;
   }
   lbyt( c );            /* send byte to listing too */
}

objflush()
{
   int i, cksum;

   if( pass != 3 ) return; /* just in case we get here */

   cksum = 0;

   if( objcnt > 0 ) {
      putc( ':', fobj );
      puthex( objcnt, fobj );
      puthex( objadr / 256, fobj );
      puthex( objadr % 256, fobj );
      puthex( 0, fobj );
      cksum =
         objcnt + ( objadr / 256 ) + ( objadr % 256 );
      for( i = 0; i < objcnt; ++i ) {
         puthex( objbuf[ i ], fobj );
         cksum += objbuf[ i ];
      }
      puthex( 0 - cksum, fobj );
      putc( '\n', fobj );
   }

   objadr = asmadr;
   objcnt = 0;}

puthex( b, c )
int b, c;
{
   int v;

   v = ( b & 0x00F0 ) >> 4;
   if( v > 9 ) v += 'A' - 10; else v += '0';
   putc( v, c );
   v = ( b & 0x000F );
   if( v > 9 ) v += 'A' - 10; else v += '0';
   putc( v, c );
}

long int hexbin( p )
char *p;
{
   long int v;

   v = 0;

   while( *p ) {
      if( isdigit( *p )) v = ( 16 * v ) + *p++ - '0';
         else if( *p >= 'a' && *p <= 'f' )
            v = ( 16 * v ) + *p++ - 'a' + 10;
            else ++p;
   }

   return v;
}

long int octbin( p )
char *p;
{
   long int v;

   v = 0;

   while( *p ) {
      if( *p >= '0' && *p <= '7' )
         v = ( 8 * v ) + *p++ - '0';
         else ++p;
   }
   return v;
}

long int bitbin( p )
char *p;
{
   long int v;

   v = 0;

   while( *p ) {
      if( *p == '0' || *p == '1' )
         v = ( 2 * v ) + *p++ - '0';
         else ++p;
   }
   return v;
}

long int decbin( p )
char *p;
{
   long int v;

   v = 0;

   while( *p ) {
      if( isdigit( *p )) v = ( 10 * v ) + *p++ - '0';
         else ++p;
   }
   return v;
}

#include "stdlib.c"
```

End Listing



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Listing One *(Text begins on page 104.)*

```
#include <stdio.h>
#include <fcntl.h>
#include <getargs.h>

/*      EXEPRINT.C      Either print or modify the exe file header:
 *
 *      exe file        Print the contents of a file's EXE header
 *      exe -mN file    Modify the exe header so that N bytes of memory
 *                      are allocated for the combined bss/stack/heap
 *                      area. If N is smaller that the required minimum
 *                      (bss + stack size) then it's rounded up. The
 *                      largest permitted value of N is 65,535. Use
 *                      -m1 for the minimum possible heap.
 *      exe -sN file    Modify the exe header so that N bytes of stack
 *                      are used. If necessary, increase the bss/stack/heap
 *                      size to accommodate the new stack. (The
 *                      bss/stack/heap won't be made smaller, however).
 */

typedef unsigned short  word;   /* 2-byte unsigned number               */

typedef struct
{
        word    signature;
        word    image_len;      /* Length of load module image % 512      */
        word    file_size;      /* File size in 512-byte units            */
        word    num_reloc;      /* Number of relocation table items       */
        word    header_size;    /* Size of the neader in paragraphs       */
        word    bss_min;        /* min size of data area above program    */
        word    bss_max;        /* max size of data area above program    */
        word    stack_disp;     /* displacement in para. of stack seg.    */
        word    init_sp;        /* Initial SP register contents           */
        word    checksum;       /* Checksum for file                      */
        word    init_ip;        /* Initial IP register contents (PC)      */
        word    code_disp;      /* displacement in para. to code seg.     */
        word    first_reloc;    /* displacement (bytes) to 1st reloc item */
        word    overlay;        /* overlay number.                        */
}
EXE_HEADER;

static int      Hsize = 0 , Ssize = 0 ;

ARG     Argtab[] =
{
        { 'm' , INTEGER, &Hsize, "Set miminum heap size to <num>"  },
        { 's' , INTEGER, &Ssize, "Set stack size to <num>"         }
};

#define TSIZE   (sizeof(Argtab)/sizeof(ARG))

/*----------------------------------------------------------------------*/

usage()
{
        fprintf( stderr, "exe [-ms[<num>]] file\n" );
        exit(1);
}

/*----------------------------------------------------------------------*/

main( argc, argv )
char    **argv;
{
        EXE_HEADER      h;
        int             fd;
        unsigned        numpara, ostack, odata ;

        argc = getargs( argc, argv, Argtab, TSIZE, usage );

        if( argc != 2 )
                fatal_err("exe: exactly one file name required\n");


        if( (fd = open( argv[1], O_RDWR | O_BINARY )) == -1 )
                fatal_err( "Can't open %s\n", argv[1] );

        if( read( fd, (char *) &h, sizeof(h) ) != sizeof(h) )
                fatal_err( "Can't read %s\n", argv[1] );


        if( Hsize )
        {
             /*  1) numpara = the number of paragraphs required to hold the
              *              specified number of bytes.
              *  2) h.bss.max, the maximum heap size, gets either the
              *              current minimum or the specified size,
              *              whichever is larger.
              *  3) write out the modified header.
              */

             numpara = Hsize/16 + (Hsize % 16 != 0) ;                /* 1 */

             h.bss_max = (numpara<h.bss_min) ? h.bss_min : numpara;  /* 2 */

             lseek( fd, 0L, 0 );                                     /* 3 */
```

(continued on page 102)

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Listing One *(Listing continued, text begins on page 104.)*

```
                write( fd, (char *) &h, sizeof(h) );
        }

        if( Ssize )
        {
                /* 1)   ostack  = number of paragraphs in original stack
                 * 2)   odata   = number of paragraphs of data.
                 * 2)   numpara = number of paragraphs in new stack.
                 * 4)   modify stack size.
                 * 5)   Adjust the size of the stack+data area as appropriate.
                 * 6)   write the modified header out to the file.
                 */

                ostack  = h.init_sp/16 + (h.init_sp % 16 != 0) ;        /* 1 */
                odata   = h.bss_max - ostack ;                          /* 2 */
                numpara = Ssize/16 + (Ssize % 16 != 0) ;                /* 3 */

                h.init_sp = Ssize ;                                     /* 4 */

                h.bss_min = odata + numpara;                            /* 5 */

                if( h.bss_min > h.bss_max )
                        h.bss_max = h.bss_min;

                lseek( fd, 0L, 0 );                                     /* 6 */
                write( fd, (char *) &h, sizeof(h) );
        }

        print_hdr( &h );
        close( fd );
}

/*----------------------------------------------------------------------*/

print_hdr( h )
EXE_HEADER      *h;
{
        printf("%6d (0x%04x): ", h->signature, h->signature );
        printf("Signature (marks this as a valid .exe file)\n");

        printf("%6d (0x%04x): ", h->image_len, h->image_len );
        printf("Length of image mod 512\n" );

        printf("%6d (0x%04x): ", h->file_size, h->file_size );
        printf("File size (512-byte blocks) including header\n");

        printf("%6d (0x%04x): ", h->num_reloc, h->num_reloc );
        printf("Number of relocation table entries\n");

        printf("%6u (0x%04x): ", h->header_size, h->header_size );
        printf("Size of the header (paragraphs) = %lu bytes\n",
                                (unsigned long) h->header_size * 16 );

        printf("%6u (0x%04x): ", h->bss_min, h->bss_min );
        printf("Min. memory above program (paragraphs) = %lu bytes\n",
                                (unsigned long) h->bss_min * 16 );

        printf("%6u (0x%04x): ", h->bss_max, h->bss_max );
        printf("Max. memory above program (paragraphs) = %lu bytes\n",
                                (unsigned long) h->bss_max * 16 );

        printf("%6d (0x%04x): ", h->stack_disp, h->stack_disp );
        printf("Displacement (paragraphs) of stack within load module\n");

        printf("%6d (0x%04x): ", h->init_sp, h->init_sp );
        printf("Initial value of the SP register (= the stack size)\n");

        printf("%6d (0x%04x): ", h->checksum, h->checksum );
        printf("Checksum for file\n");

        printf("%6d (0x%04x): ", h->init_ip, h->init_ip );
        printf("Initial value of the PC (IP) register\n");

        printf("%6d (0x%04x): ", h->code_disp, h->code_disp );
        printf("Displacement (paragraphs) of code seg. within load module\n");

        printf("%6d (0x%04x): ", h->first_reloc, h->first_reloc );
        printf("Displacement (bytes) to first relocation item in module\n");

        printf("%6d (0x%04x): ", h->overlay, h->overlay );
        printf("Overlay number.\n");
}
```

End Listing One

Listing Two

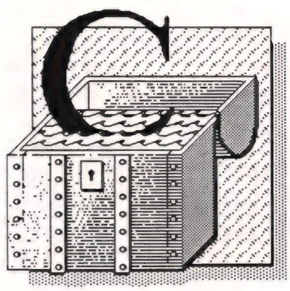
```
#include <stdio.h>
#include <stdarg.h>

fatal_err( fmt )                /* Print an error message to stderr and  */
char    *fmt;                   /* then exit.                            */
{
        va_list   args;
        va_start( args, fmt );
        vfprintf( stderr, fmt, args );
        exit( 1 );
}
```

End Listing Two

Listing Three

```
#include <stdio.h>                     /*  NRTRAV.C: A non-recursive binary */
                                       /*  tree traversal routine that uses */
typedef struct _n                      /*  the link-inversion method.       */
{
        int         tag;
        struct _n   *left;
        struct _n   *right;
        char        *key;
}
NODE;

/*-------------------------------------------------------------------------*/

#define print(nodep)    printf( "%s ", (nodep)->key );

/*-------------------------------------------------------------------------*/

descend_left( pres, prev )              /* Descend left till we can't   */
NODE    **pres, **prev;                 /* go any farther, reversing    */
{                                       /* links.                       */
        register NODE   *next;

        while( next = (*pres)->left )
        {
                (*pres)->left = *prev;
                *prev         = *pres;
                *pres         = next;
        }
}

/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*/

descend_right( pres, prev )             /* Descend right one node,      */
NODE    **pres, **prev ;                /* reversing links.             */
{                                       /* Return 0 if we couldn't go.  */
        register NODE   *next;

        if( !(next = (*pres)->right) )
                return 0;

        (*pres)->tag   = 1;
        (*pres)->right = *prev;
        *prev          = (*pres);
        *pres          = next;
        return 1;
}

/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*/

trav( pres )
NODE  *pres;
{
        NODE    *prev = NULL, *next;

        do
        {
                descend_left( &pres, &prev );
                print( pres );
        } while( descend_right( &pres, &prev) );

        while( prev )
        {
                if( prev->tag == 0 )                  /* go up from a */
                {                                     /* left child   */
                        next       = prev->left;
                        prev->left = pres;
                        pres       = prev;
                        prev       = next;

                        while( 1 )                    /* and back down */
                        {
                                print( pres );
                                if( !descend_right(&pres, &prev) )
                                        break;

                                descend_left( &pres, &prev );
                        }
                }
                else                                  /* go up from a   */
                {                                     /* right child    */
                        next        = prev->right;
                        prev->tag   = 0;
                        prev->right = pres;
                        pres        = prev;
                        prev        = next;
                }
        }
}
```

End Listings



Shrinking .EXE File Images

It's been pointed out to me that the shell occupies much more memory at run time than is actually needed. Fortunately, the problem is easy to fix without having to recompile, and the techniques used are applicable to all .EXE files.

The problem has to do with how .EXE files are loaded into memory by MS-DOS and with how memory is used by *malloc( )* and *free( )*. (See this month's Flotsam and Jetsam, page 108, for a description of memory organization within a C program.)

The MS-DOS loader reads the text and data segments from the disk and then allocates all remaining memory for the bss segment, stack, and heap, even if the program is a small-model program that couldn't possibly use all that memory. When an .EXE file is loaded, DOS can reduce this default to an amount of memory specified in a header found at the beginning of the file (in the first 14 words). This amount has to be large enough to accommodate the entire bss and stack segments. The heap, however, doesn't need to be allocated at load time because more memory is requested from DOS if the heap isn't large enough when *malloc( )* is called, thereby increasing the size of the run-time image.

The .EXE file header is initialized by the linker so that all available memory is allocated to the current program. Most small-model programs will then reduce this amount to a 64K

by Allen Holub

combined data/bss/stack/heap area as part of the boot process. Unfortunately, 64K is always allocated, whether or not you need it. The shell, in its released form, has this 64K data space allocated to it, even though it only needs about 3K for static data and another 3K for the heap. Consequently it takes up almost 90K of memory rather than the 50K or so that's actually needed.

The automatic assignment of 64K can be circumvented by having the linker put a more reasonable number into the .EXE file header (by using the */CP* or */STACK* command-line options). It's not always convenient to relink, however, especially if you don't have the original source or object modules. Fortunately, the size of the run-time image can be reduced by doing nothing more than changing a couple of numbers in the .EXE file header.

The Microsoft C compiler comes with a nifty little program called exemod that does just that—messes around with the .EXE file header to change the default run-time size of the program. Unfortunately the Microsoft version is needlessly difficult to use (requiring you to specify stack sizes in hex bytes and heap sizes in decimal paragraphs), and, of course, if you don't have the compiler, you don't have exemod either. An easier-to-use version of exemod is in Listing One (page 100).

The program (called exe) can be used in one of three ways (shown in Table 1, page 107, along with a sample output). If no command-line switches are present, then exe just prints the contents of the header. I'll look at this header in greater depth in a moment. The *−m* flag is used to change the default data area size (the combined sizes of the stack, heap, and bss areas). If N is too small (less than the combined bss and stack sizes), then it's rounded up to the minimum. You can use *−m1* to get the smallest possible run-time image, though the image will grow larger if the program ever calls *malloc( )*. The *−sN* switch increases or decreases the stack size to N bytes. If necessary, the run-time image will be made larger to accommodate a larger stack. The image isn't made smaller when you reduce the stack size. You can run exe twice, however, reducing the stack size the first time and then reducing the total file size the second time. For example:

```
exe −s1024 file.exe
exe −m1 file.exe
```

reduces a file's stack to 1,024 bytes and then eliminates the space allocated to the heap. Be careful about reducing the stack of a Microsoft-compiled program to less than 1K—I always seem to get a stack overflow error message when I do this. God knows what all that stack space is used for—my own part of the program isn't using it.

Note that the largest N that can be associated with either switch is 65,535. The only reason for this limitation is that I've used *getargs( )* to process command-line arguments and *getargs( )* can't handle *long*-size arguments very easily. If you want larger images, replace the *getargs( )* call on line 68 with your own command-line processing routine.

The .EXE file header is defined by the structure on lines 22−39, reproduced in Code Example 1, page 107. The *signature* is a unique number used to identify this file as an .EXE file. The *file_size*, *header_size*, and *image_len* fields are used to determine the size of the load module (the combined text and initialized data areas). In particular, the load image requires

```
((file_size * 512) − (header_size * 16))
                            + image_len
```

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371	372	373	374	375	376	377	378	379	380
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*The benchmark procedure was adapted from "Benchmarking Database Systems: A Systematic Approach" by Bitton, DeWitt and Turbyfill, December 1983.

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bytes. In Table 1, this comes to

((22 * 512)−(32 * 16)) + 124

or 10,876 bytes.

Several of the fields are used for patching up a few instructions that the linker can't patch. There are *num_reloc* of these items (three in exe.exe) organized as a linked list with the first node in the list at offset *first_reloc* from the beginning of the load module.[1]

The *bss_min* and *bss_max* fields are used to allocate the combined heap, stack, and bss space. The initialized data, because it's stored on the disk, is considered to be part of the load module, so its size isn't duplicated here. *Bss_min* is the minimum amount of required memory in paragraphs (16-byte chunks). It's the combined bss and stack sizes. *Bss_max* determines the maximum amount of allocated memory (also in paragraphs), so if it's larger than *bss_min*, the difference between the two numbers is the amount of heap that can be allocated before DOS has to be called. The default values of *bss_min* and *bss_max* for exe.exe are shown in Table 1 (196 and 65,535, respectively). This means that the program requires a minimum of 196 paragraphs (3,136 bytes) for the combined bss/stack area and will use all the rest of memory for the heap. The smallest-possible image can be created by setting *bss_max* to *bss_min*.

The *init_sp* and *stack_disp* fields are used to set up the stack size. *Init_sp* is both the stack size and the initial value of the *SP* register (the *SS* register points at the bottom of the stack area). *Stack_disp* is used to locate the bottom of the stack. It is added to the initial contents of the *CS* register to initialize the *SS* register when DOS loads the program. Note that the stack size is included in the *bss_min* and *bss_max* figures, so these will have to be modified if *init_sp* is made larger.

All these transformations are done by the code in Listing One. The file is opened on line 74, the .EXE header is read on line 77, the *bss_min* and *bss_max* fields are modified on lines 81−97, and the stack variables are modified on lines 99−122. The .EXE header is written back out on both lines 95−96 and 120−121 (you have to seek back to the start of the file before writing). Finally, the header contents are printed by *print_hdr( )*, called on line 124.

The *fatal_err( )* subroutine is given in Listing Two, page 102. It is used just like *printf( )* is used. It writes a message to *stderr* and then exits to the operating system. Note that I've used the ANSI (as compared to Unix) conventions for subroutines with a variable number of arguments. *Va_list* and *va_start* are macros defined in stdarg.h, supplied with the compiler. If your compiler doesn't support these, substitute calls to *fprintf( )* and then *exit( )* for the *fatal_err( )* calls. I'll talk more about subroutines with a variable number of arguments in a future column.

Erratum

The nonrecursive binary-tree traversal routine presented in July has a serious bug in the algorithm. It couldn't handle the case of a leaf that had a right, but no left, descendant. Listing Three, page 103, is another version of the routine that seems to work correctly. The basic process is

still the same (descend the tree reversing pointers so you can go back up again, setting a tag bit just before going right), but the code has been shuffled around a bit. Note that in this version I'm keeping a *tag* field in the structure rather than setting the high bit of the first character of the key string. Look back in the July C Chest if you need a more detailed explanation of what's going on.

Availability

All the code from this month is available on CompuServe in DL1 (type ddjforum). The *getargs( )* subroutine, used but not printed this month, was originally published in the May 1985 C Chest. The version used here has a fifth argument not present in the original version. If you're using the earlier version, just omit the extra argument. The current version of *getargs* is available both on CompuServe and as part of the /util program disk distributed by *DDJ* (see ad, page 124).

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's*

exe −mN file	Modify the maximum memory used to N bytes. If this number is smaller than the combined bss and stack sizes, then it's rounded up. Use *−m1* for the smallest possible load module. The maximum value of N is 65,535.
exe −sN file	Modify the stack size to be N bytes.
exe file	Just print out the contents of the .EXE header. The command line *exe exe.exe* generated the following:

23117 (0x5a4d):	Signature (marks this as a valid .EXE file)
124 (0x007c):	Length of image mod 512
22 (0x0016):	File size (512-byte blocks) including header
3 (0x0003):	Number of relocation table entries
32 (0x0020):	Size of the header (paragraphs) = 512 bytes
196 (0x00c4):	Min. memory above program (paragraphs) = 3,136 bytes
65535 (0xffff):	Max. memory above program (paragraphs) = 1,048,560 bytes
715 (0x02cb):	Displacement (paragraphs) of stack within load module
2048 (0x0800):	Initial value of the *SP* register (= the stack size)
−14653 (0xc6c3):	Checksum for file
2008 (0x07d8):	Initial value of the *PC* (*IP*) register
0 (0x0000):	Displacement (paragraphs) of code seg. within load module
30 (0x001e):	Displacement (bytes) to first relocation item in module
0 (0x0000):	Overlay number

Table 1: *Using exe*

```
typedef unsigned short word;  /* 2-byte unsigned number */

typedef struct
{
    word   signature;
    word   image_len;     /* Length of load module image % 512      */
    word   file_size;     /* File size in 512-byte units            */
    word   num_reloc;     /* Number of relocation table items       */
    word   header_size;   /* Size of the header in paragraphs       */
    word   bss_min;       /* min size of data area above program    */
    word   bss_max;       /* max size of data area above program    */
    word   stack_disp;    /* displacement in para. of stack seg.    */
    word   init_sp;       /* Initial SP register contents           */
    word   checksum;      /* Checksum for file                      */
    word   init_ip;       /* Initial IP register contents (PC)      */
    word   code_disp;     /* displacement in para. to code seg.     */
    word   first_reloc;   /* displacement (bytes) to 1st re-
                             loc item                               */
    word   overlay;       /* overlay number.                        */
}
EXE_HEADER;
```

Code Example 1: *The .EXE file header*

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Note

1. For more information about how the relocations are processed consult Chapter 10 of IBM Corp.'s *DOS Technical Reference* (Boca Raton, Fla.: IBM Corp., 1985). Much better descriptions of relocatable object module formats in general are in Steven Armbrust and Ted Forgeron's ".OBJ Lessons," *PC Tech Journal* 3:10 (October 1985), 63–81, and Intel Corp.'s *8086 Relocatable Object Module Formats* (Santa Clara, Calif.: Intel Corp., 1981), order number 121748-001.

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(Listings begin on page 100.)

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Flotsam and Jetsam

Memory Organization in a C Program

Most C programs are segmented into five parts: the code area (called the *text* segment); the initialized data space (called the *data* segment); the uninitialized data space (or *bss* segment; the stack space (or *stack* segment); and the area of memory used by *malloc( )*, called the *heap*.

The stack is used for subroutine calling, in the normal way, but it's also used to store local automatic variables. When a subroutine is called, it subtracts a constant from the stack pointer to make room on the stack for its own local variables and then accesses those variables indirectly through either the stack pointer or a special register called the *frame pointer*.

Variables at fixed addresses (globals and local statics) are in either the data or bss segments, depending on whether they are initialized by your program. Variables can be initialized explicitly (with an equal sign as part of the declaration) or implicitly. An example of the latter is a string constant, such as a format string passed to a *printf( )* call. Here the compiler automatically allocates and implicitly initializes an area of memory to hold the string, and that memory is put into the data segment (rather than the bss segment).

Usually, both the text and data segments (code and initialized data areas) are stored on the disk together. When the program is loaded, the variables in the data segment are loaded directly into their correct place in memory. There's no code generated to initialize static data; the data that is read in from the disk has the correct initial value. This explains why a static local variable has its initial value the first time a subroutine is called but on subsequent calls the variable contains the same value that it had at the end of the previous call. It's read in having the initial value, but once you change it, it stays changed.

The remaining three memory areas (bss, stack, and heap) are created as part of the loading process. After the loader has transferred the text and data segments from the disk into memory, it allocates enough additional memory above the data segment to contain the other three segments. The loader usually sets up the stack pointer to point into the stack. The program itself (or more correctly, the *root* or *start-up* module) initializes the entire bss segment with 0s and then calls your *main( )* subroutine.

The usual order of segments, going from low to high memory, is:

text	(code)
data	(initialized data)
bss	(uninitialized data)
stack	(local variables)
heap	(used by *malloc( )*)

However, the stack and heap are often reversed. The text and data areas are always adjacent because they're read from the disk as a single unit.

Naming Names

Forth has been designed by programmers who were using it, and so Forth's design is responsive to programmers' needs in small ways as well as large. Other languages don't seem to be quite so programmer-friendly. For example, I was surprised to read in an article about Modula-2 (by this column's own Namir Shammas) the complaint that the underscore character was not allowed in names. How did Modula-2's designer conclude that programmers are helped by disallowing some characters in names? In my heart of hearts, I suspect that the rule was for the benefit of the compiler writers, not the compiler users, and exemplifies fitting the task to the program rather than the other way around. This type of programming focuses on what is easy now (for the program writer), not what is easy over the life of the program (for the program users).

Service workers must always fight the tilt toward serving themselves before the clients of their profession. College administrators who bemoan the loss of serenity when students return to the campus, shelf stockers whose tempers flare when customers disorganize displays by buying items from them, and programmers who have had it up to here with figuring how to help the endlessly confused user—all should remind themselves of the point of the enterprise.

Programmers using a particular language pray that its developers kept in mind that they were writing for programmers and made their first objective easing the programmer's life, not their own task. The programmer users hope that the language developers, weary of considering all the ins and outs of implementation, did not finally throw in the towel and say, "This will be good for you, really. You'll like not being able to use underscores. Anyway, you'll get used to it."

by Michael Ham

In Forth, any character can be used in a name—well, almost any. Blank doesn't work because it is the name delimiter, and carriage return doesn't work because it marks the end of the line. Generally speaking, however, Forth is not picky about the characters you want to use.

Some standard usages have evolved in which some characters represent a class of tasks. A word beginning with a period normally displays information: *.DATE*, for example, can be assumed to display the date, *.NAME* a name, *.S* the stack (abbreviated because so often used), *.FILENAME* a file name, and so on. The greater-than symbol is often used for "to"—to indicate movement (*>R* puts a character from the data stack onto the return stack, *R>* takes it off the return stack and returns it to the data stack) or transformation (*S>D* converts a single-precision number to a double-precision equivalent, *>JULIAN* converts a date to a Julian date). The symbol *?* denotes a Boolean flag, and in a program in which names are carefully chosen, its meaning is obvious. For example, *STOP?* would leave a flag true, meaning stop, and *?STOP* would consume a flag true, causing a stop.

Code Example 1, below, shows a tiny tool *YES?* that collects a yes/anything response and leaves a true flag if the user answers yes. The word suggests a yes response (hence the name) by displaying *Y* as the default answer. *YES?* uses *CAP* to capitalize any lowercase input before checking whether it was a *Y*.

Some of these name patterns come from conventions, but conventions are more successful when they recognize and reinforce usage than when they attempt to create it. Rushing the process or trying to fence it in with rules does not lead to better results more quickly but merely frustrates and confuses the evolutionary movement. Forth gives the programmer complete freedom in naming, and the conventions for naming emerge gradually.

Other languages give the compiler writer the authority to decide the sorts of names that would be good for programmers (or, possibly, good for compiler writers) with the result that some characters fall beyond the pale that pens the programmer. "You want underscores in the name? That sort of thing isn't done in Modula-2. Don't be perverse."—the mark of bluestockings, ready to ease their life by adding difficulties to yours. Fight back. Use Forth.

Some programming languages build in conventions through tactics such as precedence rules. One popu-

```
: CAP ( c — C ) DUP 96 > OVER 123 < AND IF BL - THEN ;

: YES? ( — f ) ASCII Y EMIT 8 EMIT ( backspace )
   KEY CAP DUP ASCII Y = SWAP 13 = ( cr? ) OR DUP
      IF ASCII Y ELSE ASCII N THEN EMIT SPACE ;
```

Code Example 1: *Two tiny tools*

lar language has upward of 20 precedence rules. It's too many. The doctor in John Barth's novel *End of the Road* (New York: Avon Books, 1964) suggests to Jacob Horner that three will suffice: " 'If the alternatives are side by side, choose the one on the left; if they're consecutive in time, choose the earlier. If neither of these applies, choose the alternative whose name begins with the earlier letter of the alphabet. These are the principles of Sinistrality, Antecedence, and Alphabetical Priority.' "

Of course, it is always legitimate to propose rules. Ideas can be stimulated through discussion, but their acceptance should ultimately be based upon experience, not fiat. To demonstrate that I am willing to entertain rule proposals, I offer the following suggestions for naming conventions for the arithmetic operators.

The names of the arithmetic operators are perhaps inescapably pedestrian. Forth requires a variety of names because data are not typed and thus the operators are. Operators come in several flavors: single precision, double precision, quad precision, and mixed precision (operations in which the two operands are of different precision, typically one being single precision and the other double precision). Happily, all the mixed-precision operators can be defined to take the lesser precision operand on top of the stack, the greater precision second on the stack.

To simplify the discussion, let's follow FORTH Inc.'s lead and call single-precision numbers *singles* and double-precision numbers *doubles*. There are no mixed-precision numbers, of course, only mixed-precision operations (with a single and a double or a double and a quad as arguments).

The precision of the result of an operation is another question. Normally sums and differences are assumed to have the same precision as the operands that produced them, though that is not logically necessary: a sum of two singles could, for example, be a double. In multiplication you more commonly will want to allow the result to be of a higher precision than the factors (the product of two singles being a double, for example). And with division you might be content for the quotient to drop back a notch: double divided by single with the quotient a single. Note, however, that it seems best for the remainder to be accepted as a double even if the quotient is taken as a single.

The sign lurks as the high bit of the binary representation of the number, but unsigned numbers use that bit in its numeric meaning. Addition and subtraction do not need to distinguish—the programmer can choose how to interpret the high bit when the result is displayed. But in other operations it can make a difference: is it 10 compared to 65,535 (10 is less) or 10 compared to −1 (10 is greater)? If an operation treats the high bit as number rather than as sign, the operation is called unsigned.

Ideally, the Forth names for the operators could offer the programmer some reliable signposts through this maze of options: single, mixed, double, unsigned, signed, incoming, outgoing. The current crop of names was not designed to offer this kind of

(continued from page 111)

help. An alternative scheme is suggested in Tables 1 and 2, below.

Table 1 contains a list of prefixes for the arithmetic operators, based on the precision of the operands. When both operands are signed, single-precision numbers, the operators are unadorned. Otherwise, the operator names include information that describes the nature of the operands.

Table 2 contains a list of suffixes. Just as the prefix describes the nature of the operands (the input), the suffix describes the nature of the result (the output). Again, a garden-variety operator that produces the natural result (for example, an operation on single-precision numbers that produces a single-precision result or on doubles that produces a double). This convention assumes that the "natural" result for a mixed-precision operation has the higher of the precisions of the two operands. For example, the natural result of a single-double mixed operator is a double, and thus no suffix is used in that case. If a single-double operator produces a single result, then it is named with a suffix *S* to show that the result is single precision.

Operands	Sign Assumption	Prefix
Single-precision	signed operands	none
	unsigned operands	U
Double-precision	signed operands	D
	unsigned operands	DU
Quad-precision	signed operands	Q
	unsigned operands	QU
Mixed-precision		
Single-double	signed operands	M
	unsigned operands	MU
Double-quad	signed operands	MD
	unsigned operands	MDU

***Table 1:** Prefixes for arithmetic operators*

Operands	Result	Suffix
Single-precision	single precision	none
	double precision	D
Double-precision	single precision	S
	double precision	none
	quad precision	Q
Mixed-precision		
Single-double	single precision	S
	double precision	none
Double-quad	double precision	D
	quad precision	none

***Table 2:** Suffixes for arithmetic operators*

*D	Two signed single-precision factors producing a double product.
U*D	Two unsigned single-precision factors producing a double product.
MU*	Mixed-precision factors (single and double), unsigned, with double product. By convention, the single-precision factor is on top of the stack, the double under it.
MDU*	Mixed-precision factors (double and quad), unsigned, with quad product.
MU>	Mixed-precision unsigned compare. The sense of the comparison is double > single, both considered as unsigned.
D*/	Factors and result are all doubles, with quad-precision intermediate product (The */ operator always takes the intermediate product to the next higher level of precision. Because operators in the */ family have three operands, it seems best to avoid mixed precision on the input side.)
D*	Factors and product all signed doubles.
M*	Single on top of stack, double beneath, with double-precision product, all signed.
D/	Two signed doubles divided, producing double as quotient.
D/S	Two signed doubles divided, producing signed single as quotient.
M/S	Double divided by single with single quotient, all signed.
D/MOD	Two doubles divided, producing a double quotient and a double remainder.

***Table 3:** Examples of operator names*

These names group double-precision operators under *D* and mixed-precision operators under *M*. The affixes allow you to decipher the special qualities of an arbitrary operator and also make it easy to remember the operation names. Table 3 shows a variety of operator names that test this scheme.

Mixed precision normally is an issue only with the input because the output is normally only one number. The */MOD* operators, however, produce two numbers as output: a quotient and a remainder. Would it be reasonable to see mixed precision here, with the quotient being one precision and the remainder another?

In integer division, the max of the dividend and the divisor will be larger than the quotient and the remainder, so if the dividend and divisor are both single precision, both quotient and remainder will be single precision. The single-precision */MOD* thus leaves single-precision results, and the issue does not arise.

With *D/MOD*, however, the situation is different. Dividing a double by a double might well produce a single. The remainder, however, could well be a double. Thus, you might want the operation *D/MODM*, two doubles producing a mixed result: a single-precision quotient and a double-precision remainder. Mirabile dictu, the single is again on top of the stack, the double beneath. (Perhaps single numbers, weighing less than doubles, naturally float to the top of the stack.) You can use *M* as a suffix to indicate that the mixed precision is on the output side rather than the input:

D/MODM*—three signed doubles, with quad-precision intermediate re-

sult, producing a mixed-precision result: single quotient on top of stack and double remainder beneath.

Q/MODM*—three unsigned quads, with octuple-precision intermediate result, producing a quad remainder (second on the stack) and a double quotient (top of stack).

The example *Q*/MODM* is a grotesquerie that you would probably never encounter. It serves merely to illustrate that even novel operations can be deciphered easily with this scheme.

If you accept that all *M* operators require the single number on top of the stack and the double beneath, you can define the following operators that might be useful in mixed-precision situations. But beware of the syndrome of maniacal completeness, in which you define fistfuls of operators to complete a set of logical possibilities, even if those operators are seldom or never used. I suggest that these words be defined only in applications doing a lot of mixed-precision calculation. In that setting, their descriptive names make the code more readable and thus justify their existence.

```
MSWAP  ( d n — n d )
MOVER  ( d n — d n d )
MNIP   ( d n — n )
MTUCK  ( d n — n d n )
```

Some of the names I have suggested for the arithmetic operators don't match names in the 83 Standard. I see no problem in this; the names I propose could be adopted and the older names kept as synonyms. Forth programmers can be encouraged to shift to the new names by having a tiny speed penalty associated with the older names—for example, by defining the older name as an alias of the newer name. Any speed penalty, however slight, is more than enough to make most Forth programmers switch to the faster name.

The Toolbox

This perhaps seems like a lot of attention lavished on names, particularly for a publication whose title includes the phrase "software tools." But names are an important part of a programming tool. In a well-designed hand tool, the grip gets serious attention as the primary ergonomic interface, which plays a major part in determining the effectiveness of the tool. The programmer uses names and verbal constructs to manipulate the power of the computer. If those names and constructs fit well the habits of the mind, the task is done that much more easily.

I have proposed new operators as well as new names. I believe that any Forth package should include as a standard component a complete set of double-precision operators, with quad-precision operators available as an extension for 16-bit Forths. Double precision is often needed when working with large numbers in which round-off errors must be minimized, as in accounting applications. Sometimes (in 16-bit Forths) even double precision does not offer enough range and quad precision must be used.

These are the double-precision operators I believe should be present:

```
D+ D- D* *D D/MOD D*/MOD D>
                         D= D<
2SWAP 2OVER 2DROP D2DROP 2DUP
                    D2DUP 2ROT
2, 2@ 2!
2CONSTANT 2VARIABLE
```

With these at hand, programmers can easily construct other double-precision operators that might be needed: *D/, D*/, D0=, D0>*, and so forth. I suggest D2DROP instead of 4DROP and D2DUP instead of 4DUP because the former show the intention with more clarity and less mental arithmetic.

MMSForth, published by Miller Microcomputer Services, provides a different (and complete) solution to the need for operators of higher precision. Instead of offering optional quad precision, octuple precision, and so on, MMSForth generalizes the idea of integer precision.

The Utilities option for Version 2.4 of MMSForth includes an optional extension called *N-LEN#*. The *N-LEN#* operators parallel the usual number and stack operators and use the same names except that # is included as an identifier. All the operators (*#+, #DUP, #OVER, <##, ##S, #*/MOD*, and so on) work by reference to the value of *#PREC*, which the user sets.

#PREC specifies the number of cells to be used in the arithmetic operations. Setting *#PREC* to 1 produces the normal single-precision operators, and setting *#PREC* to 2 produces the double-precision operators. But you can set it to arbitrarily high values to allow integer arithmetic of arbitrary precision.

Do not think these operations are sluggish. Test routines included with the package time the computation of Fibonacci numbers and factorials. I computed and printed the 277th Fibonacci number in 1.08 seconds and the number 46! (46 factorial) in 1.50 seconds (both on an IBM PC with the NEC V20 chip instead of the 8088). The number of (2-byte) cells of precision specified in these test routines was 50 for the Fibonacci test and 540 for the factorial test. For most uses, 540 precision seems more than ample. Allowing users to specify the number of bytes of precision they need is clearly a better solution than hand-tailoring operators of various precision.

It should be noted that Version 2.4 of MMSForth, which runs on the IBM PC and on the Radio Shack Model 4 and equivalents, is a native-mode Forth, incompatible with the normal operating systems on those machines. When MMSForth is used, it monopolizes the machine and its resources.

Names, Names, Names

One problem Forth programmers face on large projects or when working as a programming team is the number of names that are generated. John James has called this "the name explosion." Because Forth programs are best written as a collection of useful tools (short definitions with general utility), the situation is particularly acute. Compared to procedural languages, Forth systems have more names (shortness of definition) and it is more important to know them (general utility).

Forth programmers generally agree also on the importance of finding the "right" name. The criteria for rightness vary, with one major division between those who prefer playful names and those of more serious mien. Both parties agree, however, that the best names accurately and immediately convey the idea of the word's function. Both parties prefer short names to long. And both find it difficult to get precisely the right name when names must be assigned continually.

STRUCTURED PROGRAMMING
(continued from page 113)

The first problem is getting a good name. But then, once good (or even merely tolerable) names have been arrived at, they must also be remembered somehow and (in a team situation) communicated. The Forth dictionary is not really a dictionary for humans: the names are not arranged alphabetically. Some versions of Forth provide words such as *LOCATE* or *VIEW* that work reasonably well—but only if you can remember the name to begin with (does anyone have a *LOCATE* and *VIEW* that work with wildcards?) and if the documentation (comments and shadow screens) is understandable and up-to-date—or, failing that, the source code is readable.

The difficulty of using new words fluently is the same as the difficulty of speaking or writing a foreign language. Having to look up every word in a dictionary is insufferably slow. In a single-programmer shop, the programmer gradually learns his or her own language and becomes fluent in the tools he or she has created. But what is to be done in a multiperson shop, with each programmer creating several names a day? Are there regular meetings wherein the programmers present their words to each other? Do they pass around a list of their creations for others to learn and use? Do they maintain an on-line encyclopedia? When a new programmer joins the group, how is that person trained in the local language? How long does it take a programmer new to the group to become fluent in the special words that are in use?

I am in the lone-programmer category, but I would be interested in hearing how multiperson shops handle the problem of names and the problem of promulgating the general-purpose tools the programmers create. If you have found a working solution to this problem, do share it.

I also would be interested in finding out how you lone wolves keep track of your own tools. Do you sort your tools into files, each file being a toolkit for a particular purpose? Do you use precompiled overlays as toolkits? Do you keep all your words and their use in your head, or do you maintain some kind of written refer-

ence book—a dictionary, or thesaurus, or encyclopedia? Let us in on your secrets.

Fragility as Strength

Once there was a contest to define Forth in 25 words or less. My definition was "Forth is like the Tao: it is a Way, and is realized when followed. Its fragility is its strength, its simplicity is its direction." I want to talk about the seeming oxymoron in this definition: Forth's fragility being its strength.

Forth has no training wheels. If you tip over, you fall: the stack explodes, the system crashes, whatever. The design decision in creating Forth was to remove safeguards to enhance performance. For programmers accustomed to bulletproof compilers, this approach seems foolhardy. Why not have as much protection as possible?

Protection of course imposes performance penalties, but perhaps even more important is the degradation of the feedback. In high-performance machines, the flip side of responsiveness is sensitivity. The more the machine gives control to the operator, the more responsibility the operator must accept. The advantage of the operator taking control is that the operator becomes more directly connected to what is happening. This connection amplifies awareness and allows the mind and the tool to merge, providing the immediacy of feedback that more closely connects thought and action. The intimacy and control of such a connection is almost addictive, which is why people who have learned to work with such tools are so reluctant to abandon them. Racing-car drivers don't enjoy spending the day behind the wheel of a station wagon.

Robert Berkey first pointed out to me how the Forth stack, leaving the arguments nakedly exposed, also lets the programmer see what is going on. Errors surface immediately—that's the fragility—and, being discovered, are then corrected—that's the strength. Merely because Forth is fragile for the programmer does not mean that the application programs are fragile. Indeed, the very degree to which errors will out during development makes the final product that much more robust.

Fragility often accompanies flexibility. The more options the machine or language offers, the more ways it can be used against itself (fragility), but the greater diversity of needs it can address and the more quickly it can be modified (strength). A mechanical example is the Gossamer Condor, a successful human-powered aircraft. A key design decision was not to attempt to make it an unbreakable machine but to make it as simple as possible, with everything visible and accessible. Let it break, as long as it is easy to fix. That simplicity also made it flexible in the sense that it was easy to modify, and in fact the Gossamer Condor's success was based upon a process of iterative development familiar to Forth pro-

1000 0000	No more data in this 512-byte block.
0xxx xxxx	Data field consists of as many bytes as specified by the number in the low bit positions (and thus a maximum of 127 bytes). Though unimportant for decoding, it is worth noting that the data bytes contain no duplicates.
1xxx xxxx	Data field consists of a single byte (the next byte after this flag), which is to be replicated as many times as the number in the low bit positions (and thus a maximum of 127 replications).

Table 4: *Flag bit structure*

```
( Work areas )
   CREATE OUTAREA 20000 ALLOT     ( will contain uncoded image )
   OUTAREA 20000 ERASE            ( size depends on application )
   CREATE INAREA 512 ALLOT        ( work area for input blocks )

( Pointers )
   VARIABLE INBYTE        ( current byte in work area )
   VARIABLE OUTBYTE       ( current byte in output area )
:  INPOINT     ( — adr ) INBYTE @ INAREA + ;      ( next source byte )
:  OUTPOINT    ( — adr ) OUTBYTE @ OUTAREA + ;    ( next target byte )

( Flag manipulation )
( These use the encoding flags )
:  NEXTFLAG     ( — f )     INPOINT C@ ;       ( puts flag on the stack
                                               )
:  BLOCKEND?    ( f — f )   128 = ;            ( end of input block )
:  REPLICATE?   ( f — f )   128 AND ;          ( replicate next byte )
:  CHARCOUNT    ( f — n )   127 AND ;          ( # of replications or )
                                               ( # of bytes to move )

( Replication )
:  REPLICATE ( f — )                ( replicates based on count in flag )
     INBYTE INCR                      ( move past the flag )
     INPOINT C@                       ( char to replicate )
     OUTPOINT                         ( destination address )
     ROT                              ( bring flag to top )
     CHARCOUNT OVER + SWAP            ( indices = address range )
     DO DUP I C! OUTBYTE INCR LOOP    ( replicating & counting )
     DROP                             ( character replicated )
     INBYTE INCR ;                    ( to next flag location )

( Move )
:  MOVECHUNK ( f — )                ( moves # of chars specified in flag )
     CHARCOUNT DUP INBYTE INCR
     INPOINT OUTPOINT ROT CMOVE       ( move characters )
     DUP INBYTE +! OUTBYTE +! ;       ( update pointers )

( Actual decoding of block )
:  BLOCKWORK                   ( decompress the run-length encoding )
     BEGIN NEXTFLAG DUP BLOCKEND? NOT OUTBYTE @ 20000 < AND
     WHILE DUP REPLICATE? IF REPLICATE ELSE MOVECHUNK THEN
     REPEAT DROP ( flag ) ;
```

Code Example 2: *Decoding run-length encoded data*

(continued from page 115)

grammers. (The best account of the development of the Gossamer Condor and its sibling the Gossamer Albatross is the book *Gossamer Odyssey* by Morton Grosser [Boston: Houghton Mifflin, 1981]).

In this spirit, tools for developers typically lack the safeguards that programmers provide in application programs: *DROP*, for instance, doesn't check stack depth before trying to drop. Such a check would slow it down too much. The programmer is responsible for making sure that the program will always have something on the stack when *DROP* is used.

On the other hand, some safeguards don't cost much. Paul Simon pointed out in a letter that the defining word *FOR*, which appeared in this column in July 1986, could include an error check with no speed penalty.

In its final version, *FOR* expects two numbers on the stack and will crash the system if it is executed with an empty stack. This behavior, perfectly acceptable when *FOR* was mine alone, becomes arguable when *FOR* is promulgated as a tool for general use. It is easy to provide some protection. The simplest approach is to include at the beginning of *FOR*'s definition (right after *CREATE*) this phrase:

```
DEPTH 2 < ABORT" Need both array
            type and number of slots"
```

The speed of the words defined by *FOR* is unaffected by this additional check. On the whole, putting in this bit of protection seems reasonable. Moreover, as Forth is an open-architecture language, those who don't want to spend the memory space on the error message can remove the check. After all, they might reason, if *FOR* fails, it is during development, when the developer can immediately correct the condition. At run time (when the end-user is running the application program), it is not *FOR* but the words defined by *FOR* that are used, and they, of course, will work fine.

Though I tested *FOR* for suitability as a tool for other programmers (as a tiny application program), I never recognized the problem of what happens when the stack is empty. My oversight occurred because I fell into the vulgar error of testing to show that the routine works instead of viewing as a failure any test that fails to find a bug.

Glenford J. Myers observes in *The Art of Software Testing* (New York: John Wiley & Sons, 1979) that the primary difference between successful and unsuccessful test efforts is that single, critical definition: a successful test is one that finds a bug; a test that finds no bug is a failure. And Gerald Weinberg's enjoyable book *The Psychology of Computer Programming* (New York: Van Nostrand-Reinhold Co., 1971) points out that a programmer trying to find errors in his or her own work is unlikely to be successful, which is why independent testing is so important.

Run-Length Decoding

I close the column with a brief discussion of run-length decoding. One way of compressing data is run-length encoding. There may be varieties of this technique, but the one I ran across was as follows.

The data are stored in 512-byte blocks, coded in variable-length data fields. Each data field has as the first byte a flag that determines the type of field and the length of the field. The flag's bit structure determines its meaning (see Table 4, page 115).

The words in Code Example 2, page 115, decode such encoded data. In this particular application I knew that the decoded data would not exceed a length of 20,000 bytes. Each coded block is read in turn into the 512-byte input work area and is then decoded into the next available area of the output work area.

The pointers *INPOINT* and *OUTPOINT* keep track of where you are in the two areas. The flag-manipulation words take care of all flag interpretation. *REPLICATE* replicates, and *MOVECHUNK* moves a chunk of data. *BLOCKWORK* decodes the block and is used within a loop that reads each of the 512-byte input blocks into the input work area in turn.

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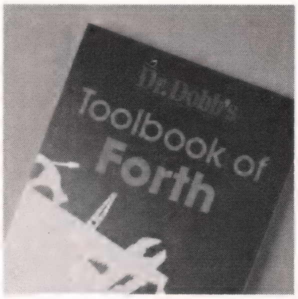

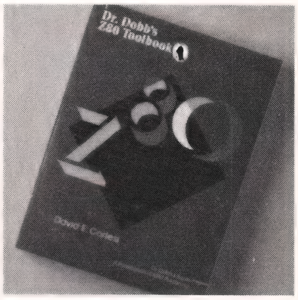

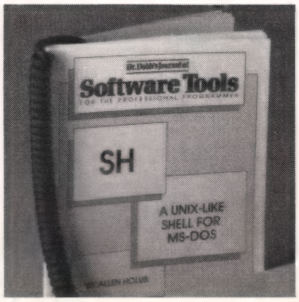

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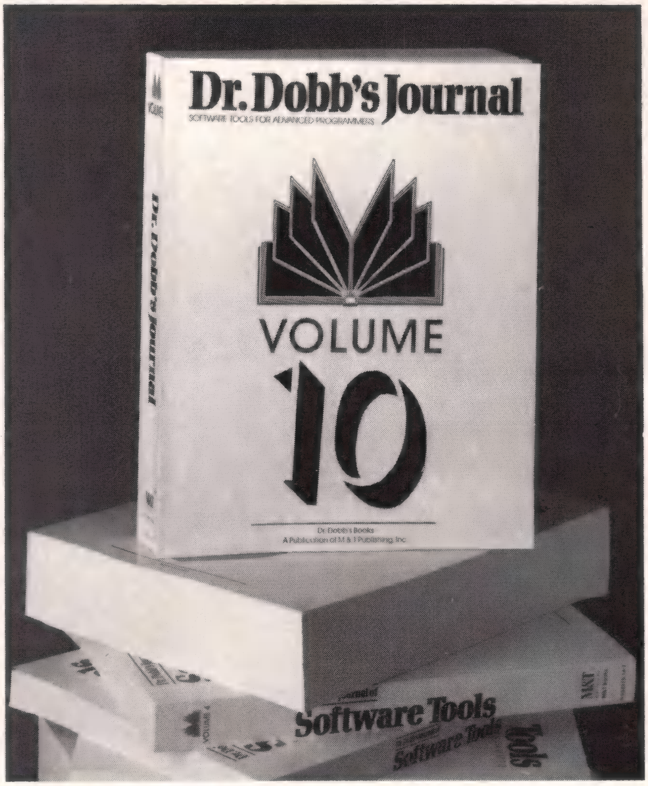

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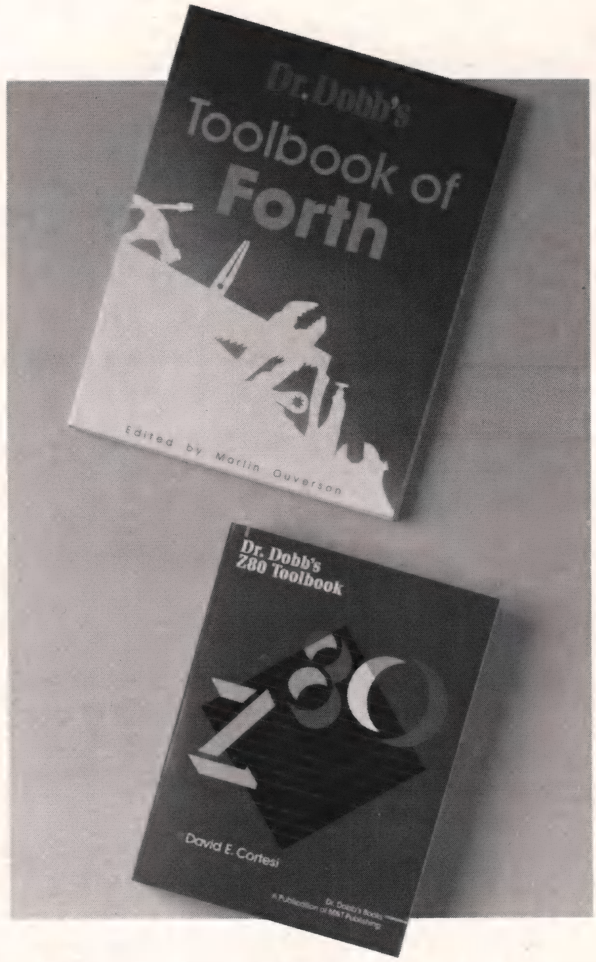

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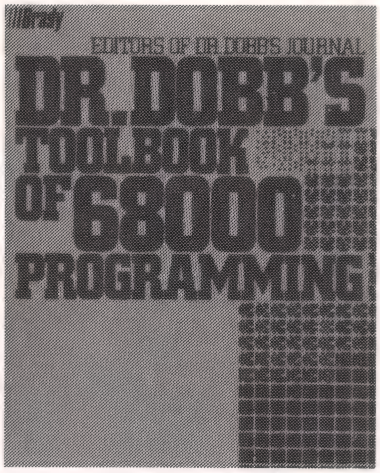

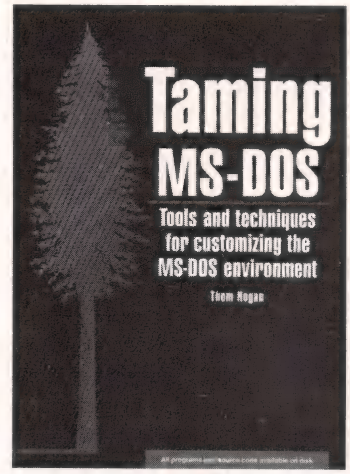

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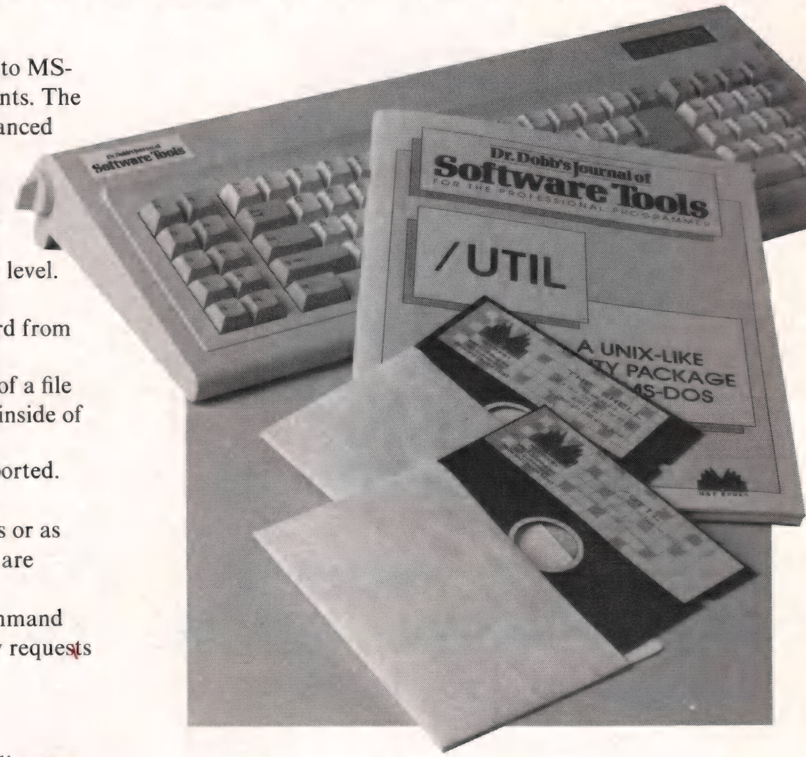
WRITING A UNIX-LIKE SHELL FOR MS-DOS



This book will show you how to write shells applicable to MS-DOS as well as to most other programming environments. The book and disk include an in-depth description and enhanced version of Holub's popular Unix-like Shell, along with complete C source code. You'll find:

- how to do interpretive control flow in any C program;
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Redirection and Pipes <> >> >& >>& |
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$d $t $| $h $n $q $$ $%

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A powerful, interpretive, programming language, based on the UNIX C Shell, is now supported, including:

if/then/else	foreach	break
while	switch/case	continue

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/UTIL

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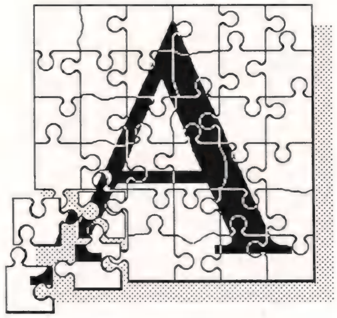

I'd like to design a versatile, easy-to-use interpreted language, using occasional essays in this space to stimulate my own creative juices and get feedback from you. My approach to this project will be experimental, and the entire interpreter will be written in 680xx assembly language. Why? Because I love 680xx assembly language, and I like to noodle around looking for really efficient ways to do stuff. As my interpreted language comes together, I want to know what you think of it. If the ideas expressed here get your juices flowing, send me a letter. If you send me interesting enough letters, I'll include them here. I'd like this to be both an educational project for interpreter designers and a general discussion of data handling in assembly language.

Why an Interpreted Language?

The nicest thing about an interpreted language is that it can be very interactive, and if it's extensible and fast enough, it can be a real joy to work with. Forth is an example of the kind of language I'm talking about. I like Forth a lot. But the problem with Forth is that it's too weird—I find I have to think backward to use it effectively, and I'd like to be able to think in my most efficient way—forward. Thus, because I've never seen a true interpreted language that satisfies me, I want to design my own, with your feedback to help guide me.

by Nick Turner

Juggling Numbers

In this first essay I want to talk about math; specifically, numeric formats. This is intended as both an introduction to numeric representation (for those who may not have a lot of low-level practice) and as a source of inspiration for experienced assembly-language programmers. I'll start things off with a summary of some of the various numeric formats that have been used on computer systems. This will be a general description; more detailed stuff will come later on. I hope to make most of these formats available in the final interpreter.

Simple Integers

The simplest approach to computer math is to use integers. Though integer (INT) math may initially seem rather limited, a surprising amount of complex calculation can be done with integers alone. On typical computer systems, there are usually three kinds of integers: bytes, words (two bytes), and long words (two words). Sometimes you might need extra-precision integers of eight or more bytes. I propose at least two kinds of integers for my interpreter: word size (INT) and long word size (LINT). Both would be signed values, with negative numbers expressed in two's-complement form. Will I need double-long, 8-byte integers (DINT)?

Simple math with integers is straightforward. The biggest advantage of INT math is speed. Overflow and underflow are typically the most important error conditions. The biggest practical disadvantage of integer math is the inability to represent fractional values directly. Fractions can be represented by multiplying all the numbers in the system by some constant, but it requires extra time and programming. Besides, if the constant multiplier is a power of 2, you've just invented the next category: fixed-point numbers.

Fixed-Point Numbers

A typical fixed-point (FIX) representation allocates a number of bits for the integer portion of a value and an equal number of bits for the fractional portion. For example, you might use a 4-byte long word in which the high-order word is the integer and the low-order word is the fraction. Some systems use larger FIX formats with a whole long word for each portion, and a few systems have unequal distributions of bits. In such cases, it's usually the fractional portion that has fewer bits. I propose one FIX format for my interpreter (mostly for speed in calculations involving fractions). My FIX could be two long words—one for the integer and one for the fraction. The high bit of the integer portion would be reserved for the sign, and the rest would be an unsigned value. (This simplifies output of ASCII translations of the number.)

FIX has the advantage of being able to deal with fractions, but it still has the problem of limited precision, especially for small numbers. From here there are two directions in which to go. Which path a system takes depends on what the numbers will be used for. If the ability to represent really huge or miniscule values is more important than vastly precise representations, then floating point is probably best. On the other hand, if incredibly high precision is necessary, you might choose what I call extended representation.

Floating-Point Numbers

By far the most frequent choice in typical systems is a floating-point representation (FLOAT), in which the value is divided into two subvalues: the exponent and the mantissa. The exponent represents the logarithm in base 2 of a number by which the mantissa is to be multiplied to create the actual value stored. For example, if the exponent is 4 and the mantissa

is 3, then the value might be 3 times 2 to the fourth power, or 3 times 16, or 48. In actual practice, the mantissa is almost always treated as a fraction. In the above case, the exponent would be 6 and the mantissa would be 0.11 (binary), which is 3 (or 11 binary) shifted left twice. Note that the exponent really represents nothing more than the number of times the mantissa must be shifted to create the actual value. If the exponent is negative, you shift the mantissa to the right. If it's positive, you shift it left. The mantissa usually also has a sign bit, which governs the sign of the entire value.

Now here's the tricky part about floating point: most FLOAT representations nowadays have something called a "hidden 1 bit." This means that the high-order bit of the mantissa, which is always a 1 bit in a properly normalized FLOAT value, is "overlaid" by the sign bit of the mantissa or is omitted altogether. The cost of this 1-bit saving is that the missing bit must be recreated every time a calculation is done. For systems with a hardware assist, such as the MC68881 floating-point math chip, this is trivial. Another tricky point is that the exponent is usually represented as an "augmented" value—this means you must first subtract a certain number from it in order to get the actual exponent. The augment number is chosen such that an exponent of zero is represented as a bit field with only the high bit set. The result is that the exponent can be treated as a simple unsigned value, simplifying many calculations.

For my interpreter, I propose the FLOAT formats used by the MC68881 chip—specifically, the single, double, and extended representations, which I will call FLOAT1, FLOAT2, and FLOATX for my language. The reason is simple: I'd like to use the 68881 chip eventually.

A Weird Extended Hybrid

The last approach to numeric representation, and one that I've not seen used very much, is sort of a weird hybrid between floating point and fixed point. I call it extended representation (EXT), and it's the only numeric format in my proposed system that uses variable-length fields. The basic concept is simple: a number is represented in full precision as a large field of 2-byte words, with a giv-

THE RIGHT TO ASSEMBLE
(continued from page 127)

en number of words representing the integer portion (except the highest order bit, which is the sign bit) and the remainder representing the fractional part. Of course, there must also be a field somewhere that contains some clue as to where the radix point is (the radix point separates the integer from the fraction). It's also important to have a value that says how long the whole thing is.

The EXT format has certain advantages for a limited set of problems. For instance, I've always wanted to be able to compute various irrational values to an arbitrarily high precision. My EXT format can do this, but problems arise. For example, as soon as you attempt to calculate a transcendental function, you run into precision vs. time trade-offs: if you use the traditional polynomial approximation method, your polynomial factors will limit the precision of the result, which must then be chopped accordingly. On the other hand, if you use the full Taylor (or similar) series to compute the transcendental result, you may end up spending an inordinate amount of time to get the desired accuracy. I'm very interested in feedback on this issue; I have by no means reached a satisfying resolution.

Do You Want More?

If there's a good response to this essay, I'll continue the story. Future topics might include a detailed expansion on each of the numeric formats described here, with listings of working math routines and a discussion of the "housekeeping" information surrounding the number formats—how does the system know what kind of number it's dealing with and how does it keep track of all the variables? I'd also like to discuss the actual syntax and interface of the language—but first I'd like to see your blue-sky suggestions. What would your ideal interpreted language look like? Write to me care of *DDJ*.

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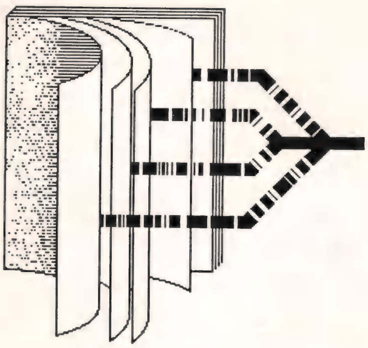

PROLOG and the Future of AI

The following is an excerpt from a real-time conference held by Borland International on CompuServe on July 26, 1986. A complete transcript of this three-hour on-line conference on AI and PROLOG can be found in DL6 of the Borland SIG on CompuServe (<GO BOR100> KEYWORDS:CONFERENCE).

Larry Kraft, SYSOP of Borland SIG: Our panel of featured "speakers" today includes Borland's president, Philippe Kahn; assistant professor Mark Chignell of USC, and Mike Swaine, editor-in-chief of *Dr. Dobb's Journal of Software Tools.* The first part of this conference will consist of a panel discussion centered on numerous questions that were submitted in advance. Our first panelist to speak will be Mark Chignell.

Mark: I'll start with a little information on my background in AI and PROLOG. I am an assistant professor in the Department of Industrial and Systems Engineering at the University of Southern California. I have a Ph.D. in psychology and an M.S. in industrial and systems engineering. At USC I became interested in PROLOG as a practical implementation language for AI applications in engineering. My current research is concerned with the development of human-computer interfaces in engineering design and on-line information retrieval.

Here's the first question I'm going to answer: What is artificial intelligence? People usually point to smart computer programs and say, "That's AI." In the early days of AI, 1956–1970, AI was thought of as a process of domain-independent, general-purpose reasoning. More recently, people have focused on domain-specific knowledge and the kind of heuristic reasoning that experts use. Perhaps the main unifying feature of all AI applications is the element of machine reasoning. In vision, for instance, the program is reasoning about how to update its model of the visual environment based on the sensory data. In planning, the program is reasoning about how to act on its model of the task environment so that a set of goals can be achieved and so on. (See P. McCorduck, *Machines Who Think*, for a historical introduction to the issues faced by AI.)

Philippe: Well, to me AI is what hasn't been done yet—once it's been written, it's called programs!

Mark: Question: What are "true" AI applications? Perhaps the thing that distinguishes AI from other applications is the *need* for symbolic reasoning. In statistics, for instance, it wouldn't make much sense to use an AI program to find the straight line that had the best least-squares fit to a set of data. That task is already done well by numerical algorithms. In machine chess, brute-force methods based on grinding through possible move sequences do yield fairly good results, but the problem of combinatorial explosion of search possibilities has led to an examination of how human masters perform the task and has led to attempts to incorporate their knowledge representations and heuristics into chess programs.

Philippe: Well, that is one way of typing things. . . . On the other hand, I think that five years ago people would have called a resident, beeping spelling checker AI.

Mark: I guess we have a difference of opinion here. I think it should be possible to characterize AI independently from the current status of technology. We should be moving toward a definition of intelligence that covers both humans and machines.

Question: How can you tell if a program is intelligent? In today's climate, there is a tendency to assign the label AI rather liberally. Deciding on whether a program is intelligent is a particular case of the general problem of recognizing intelligent behavior. One method for establishing the intelligence of a program is a type of Turing test. If the performances of a program and of a person on a task that requires intelligence are virtually indistinguishable, then we assume the program is intelligent.

Larry: Thank you very much, Mark. Mike, you're up next. Go ahead, please.

Mike: I'm Mike Swaine, editor-in-chief of *Dr. Dobb's Journal of Software Tools.* My background includes graduate study in both human cognition and artificial intelligence and three years reporting on AI and new technologies as a senior editor for *InfoWorld*. I am coauthor of *Fire in the Valley*, a history of the personal computer, and creator of the fictional puzzle-detective Mr. Usasi.

Question: What is declarative programming, and why would you want to use this type of programming? Declarative programming stresses static aspects of knowledge: facts about the world and rules about how the facts are connected. It concentrates on representing these facts and rules, and it deliberately submerges all procedural details. These procedural details are nothing less than the entire control structure of the program—that is, what statement gets executed next or, in more conceptual terms, how to use these static facts and rules to answer questions, solve problems, or derive new facts and rules.

PROLOG, for example, uses the model of first-order predicate logic to represent the facts and rules about some domain of knowledge—such as U.S. geography—and submerges the procedural details in an inference engine, a mechanism that automatically makes the necessary deductions from the facts and rules. To oversimplify, using PROLOG means pouring facts and rules into the system, asking questions, and letting the system derive the answers from the informa-

tion you have supplied. You declare; it deduces. To the extent that declarative programming actually submerges the procedural details, it achieves one of the goals of what is called fifth-generation language design: it allows the programmer to focus on the problem rather than on the program. In implementing a geographical database, for example, you can concentrate on facts about U.S. geography rather than on details of database design.

Question: What are the advantages and disadvantages of declarative vs. procedural programming? The choice of a declarative or a procedural approach to solving a particular problem can depend on what kind of knowledge about the problem is most accessible. If you can gather the important facts and rules about the problem domain easily, then you should consider a declarative approach. If it's easier to specify the steps or techniques for solving the problem, then you should consider a procedural approach. Another consideration is consistency vs. efficiency. A declarative, first-order, predicate-logic-based approach can be trusted to be consistent; you won't get false conclusions from true premises. But by giving up control over the way the program searches for solutions, you give up the option of fine-tuning the code for efficiency. A procedural approach lets you specify how to solve the problem efficiently but at the cost of introducing complexities that make it harder to trust the results.

Question: Are PROLOG and LISP both declarative? No language is strictly one or the other, although most programming languages are mainly procedural. LISP can be thought of as declarative, but it's a funny fit—LISP wants to be thought of as functional, and it's old enough to be humored. PROLOG was designed to be used declaratively. PROLOG probably gains in efficiency by not being purely declarative, but it pays for it in inconsistency because of extensions to the basic idea and, I think, to the way in which falsity is implemented.

Philippe: Well, LISP really manipulates functions, and I would call it procedural, just like its contemporary FORTRAN.

Mike: OK. Next question: Why is PROLOG appropriate for writing expert systems, and what systems have been written in PROLOG? Last week I watched an expert systems "knowledge engineer" being grilled by a roomful of skeptical C programmers. The C programmers all wanted to know "What do you do that can't be done in C?" The knowledge engineer had to admit that anything he did could be done in C and that in fact his company typically ported its products to C for efficiency and portability. The programmers already knew these things, but it made them feel good to hear them.

So why use PROLOG for expert systems if you'll eventually rewrite them in C? Well, that's almost like asking why use a graphics language for graphics processing. Expert systems logically include certain components that are built into PROLOG—like an inference engine; like a natural mechanism for adding to the knowledge base without rewriting the entire program. In fact, expert systems and PROLOG grew out of the same motivation: a desire to represent static knowledge in a computer program. Writing an expert system in PROLOG involves using some powerful tools. Rewriting it in C means recreating those tools. The latter may allow opportunities to optimize, but it also distracts attention from the real task.

As of today, though, PROLOG is not the language of choice for developing expert systems because of the past lack of a decent PROLOG programming environment. Of the hundreds of expert systems in nonacademic use in the U.S., nearly all were developed in some version of LISP, in a specialized expert-system-development language such as Teknowledge's S.1, or in a conventional third-generation language such as C. (One

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(continued from page 131)

counterexample to keep you awake nights: Lockheed is using PROLOG to develop an expert system for the Department of Defense [DoD] to analyze electronic intelligence data to determine "enemy intentions.") In Japan, PROLOG-based expert systems have been developed for (at least) medical, commercial, and engineering applications. The new PROLOG implementations coming to market may change this picture radically.

Philippe: Well, in Europe, where PROLOG was born, PROLOG has been more widely used than LISP. Furthermore, PROLOG is newer and younger, and it is just now picking up a lot of momentum.

Mark: The two other panelists classified LISP as a procedural language. As someone who has spent some time with the language, I feel some duty to defend it. LISP is really a language-development environment rather than a single language. Once you start writing functions, you can create your own language. LOGLISP is an example of a PROLOG-like language in LISP—that is, declarative versions of LISP have already been written. Object-oriented languages have also been written on top of LISP.

Mike: What does AI offer to the average programmer or user? I'll give only one of the answers; maybe others will emerge from discussion. AI is the domain of exploration of new programming techniques. When they cease to be new, they cease to be AI, but they don't cease to be useful. Also, I'd like to point out that PROLOG may be a good prototyping language for anything, not just AI applications.

I have a question. As editor-in-chief of a magazine for software developers, I am interested in the interface—in the sense of the zone of transmission—between the other two panelists' areas of expertise. I'm curious about developments in AI labs that may lead to commercial products in the future. I haven't been particularly prescient about this in the past. Having written a simple expert system in graduate school, I understood the principles. I had been following AI work closely when Teknowledge

was founded and knew the credentials of its founders; nevertheless, I did not foresee the current success of expert systems. Expert system companies are beloved of investment capitalists. Teknowledge was one of the few sales winners in a recent *San Jose Mercury News* summary of the sales slump in Silicon Valley. I'd like to do better the next time. I'd like to be able to see the next area of commercial development and practical application of laboratory developments in AI—the next Big Thing. There is a tantalizing suggestion of what that might be. . . .

Mark: That is a very good point, Mike. I think it is often hard for researchers to predict what is going to fly in the marketplace. If I were to make a bet, I would say that in the near term we may see a revolution on retrieval and utilization of information/knowledge using AI-based front ends.

Larry: OK. Philippe's turn for questions. Philippe, I believe you have some opening comments? Go ahead.

Philippe: First: My updated biography: Failed musician, mathematician, relatively artificially intelligent, self-appointed "the software industry's resident court jester"! Pops up unexpectedly anywhere.

Larry: Now, I have the questions for Philippe. What plans are there to tie PROLOG to conventional databases? Is this a growing area of AI technology?

Philippe: I don't know whether it's a growing area, but it should be very useful. The biggest problem people have with large databases, or in the AI world "knowledge bases," is reentering data. The best thing is to be able to read and write "usual" database files.

Larry: Next question: Is PROLOG a general programming language that can be used for a wide variety of programming applications or is it specifically database-oriented?

Philippe: Well, it is inference-oriented, if anything. With good extensions, PROLOG can let you do different general things, but as with any tool, you need to use the right tool for the right job. If you use a hammer when you were supposed to use a saw, you might get into trouble!

AI is the domain of exploration of new programming techniques.

Mark: You know, there are close to two billion documents on-line in the world today. This is a huge amount of information, but it's not really knowledge until you can distill the essential meaning. Perhaps the next big AI industry will be the replacement of much of the current knowledge-engineering effort with what I will call a "knowledge mining" effort, looking to translate the current backlog of electronic information into usable knowledge bases.

Philippe: There is much more in a lot of this information—things as simple as typesetting codes, tables of contents, indexes, cross-references, and so on. Millions of man-hours of editing have gone into that stuff. It is much more than dumb data, at least in many cases. You still have to interpret it, but a lot of the work has already been done. Take a book such as *Roget's Thesaurus*, for example. It divides the world into categories, and you can thus define a vector space in a given metric and talk of a much broader way to index data semantically rather than through a keyword system. But as our old friend Kipling said, "This is yet another story!"

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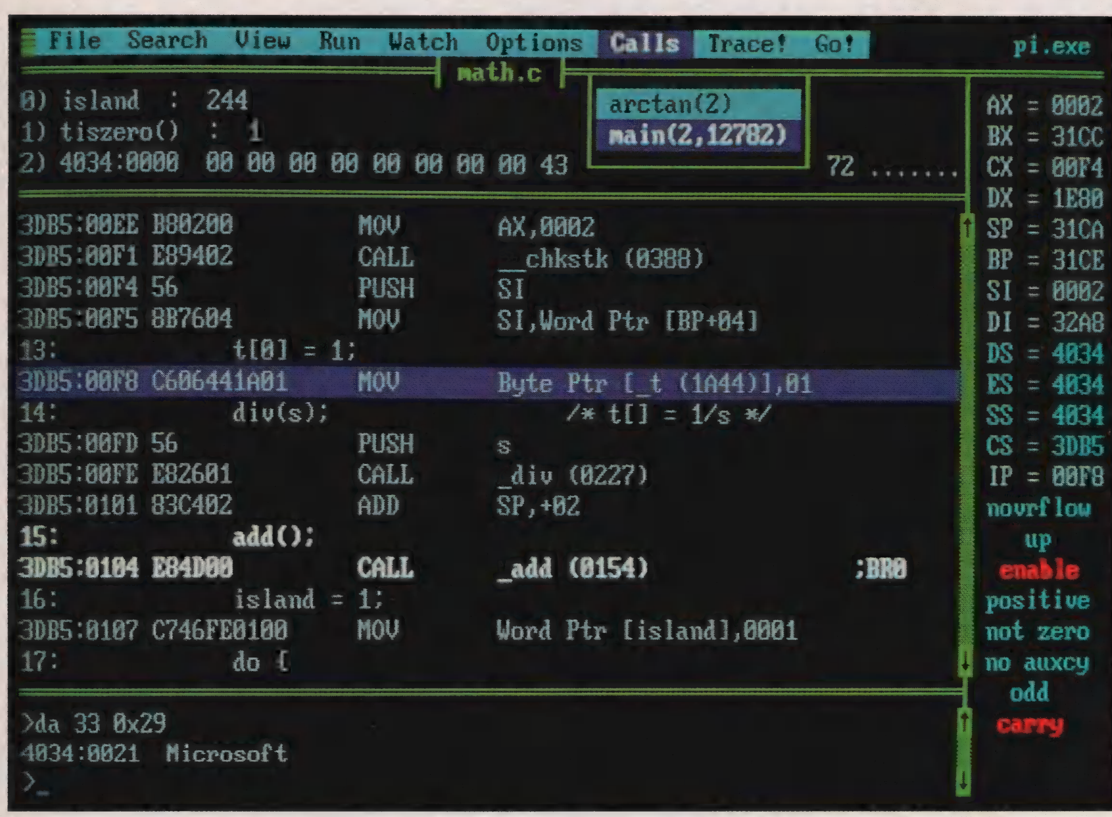

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(continued from page 14)

indeed a principle of classical logic. As such it does not support the former invalid inference. The assumption PROLOG makes is the altogether different assumption termed the *closed-world* assumption. PROLOG automatically assumes that any postulate set (knowledge base) is complete: if it cannot be derived that *S*, then it must be that *not S*. Thus PROLOG enshrines the fallacy dubbed by Spinoza as the *argumentum ad ignorantiam:* If it can't be proven true, it's false, and if it can't be proven false, it's true. Of course it follows that a proposition that can't be proven true or false is both true and false. Indeed, with the proper repositioning of postulates (rules), PROLOG will answer "yes" and "no" to the same query even though the postulate set is consistent.

The point is that if a system is not complete (there are such complete systems—real closed fields being an example), then the assumption of completeness made by PROLOG (built into its definition of negation) is false and will lead to fallacious inferences and contradictory inferences. The justification offered for PROLOG's treatment of negation is that *not* means *not known* or *not derivable*. But this lame attempt at justification doesn't hold up. Neither the epistemic nor the apodictic concept obey DeMorgan's laws, whereas the truth-functional *not* in PROLOG does.

It is simply not safe to use *not* unless it is pinned down to a range (for example, with the use of *ON*). Otherwise the negation logic needed should be provided by the programmer. Negated sentences can be treated as units—for example, use of *not-L* instead of *not L*. The relationship between *L* and *not-L* and other negation relationships must be spelled out by the programmer. The programmer must use *(either not-L or not-K)* instead of *not(L and K)* and so forth. PROLOG never actually transforms any of the rules in the knowledge base, which means that the programmer can provide the negation logic needed.

Texts and manuals for PROLOG should be up front about PROLOG's limitations. It is not a full predicate logic in any direct sense. What PROLOG is is a negation-restricted, expanded logic of definition with marvelous recursive powers. Properly billed, the foregoing facts about PROLOG's inconsistency and radical incompleteness merely become irrelevant considerations based on a confusion about what PROLOG is supposed to be. Consider the very first problem with the introduction of a postulate declaring the transitivity of *R*. Considered as a definition, the postulate violates the cannons of definition by attempting to define *R* nonrecursively in terms of itself. PROLOG can easily handle the introduction of a transitive relation when defined recursively. The transitive closure *TR* of a relation *R* is defined:

```
TR(x y) if R(x y)
TR(x z) if R(x y) and TR(y z)
```

The general theory of definition and the theory of recursive definition can be given a rigorous syntactical formulation—it would be interesting to see an exact syntactical formulation of the extension used by PROLOG. From a computer science point of view, this would amount to giving syntactical rules to rule out non-logic-based semantic errors (logic errors in the field of partial recursive functions cannot be ruled out by syntactical rules).

The deductive-axiomatic method has been the central unifying methodology of knowledge of the Western intellectual tradition. By removing the barrier to the real-time use of the deductive-axiomatic method, PROLOG may have an impact on knowledge use and acquisition that is hard to overestimate. After all, being able to query Aristotle, or Goethe, or Einstein with an updated database does give new meaning to the expression deus ex machina.

Those who package PROLOG should have the courtesy and integrity to say what it is and what it isn't.

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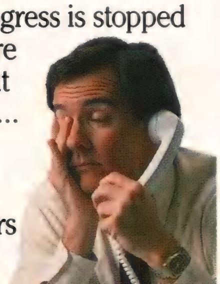

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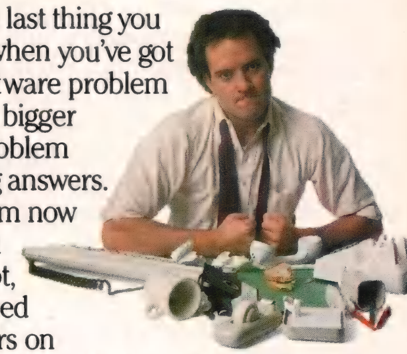

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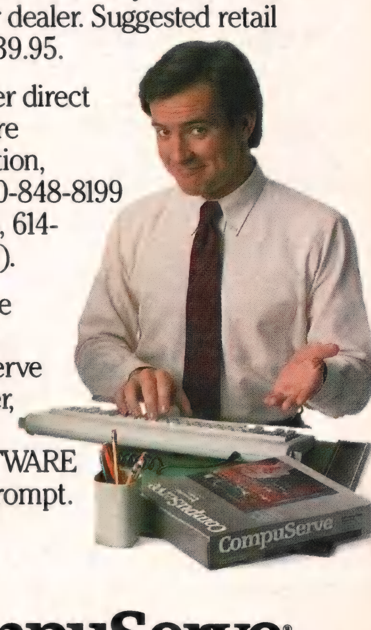

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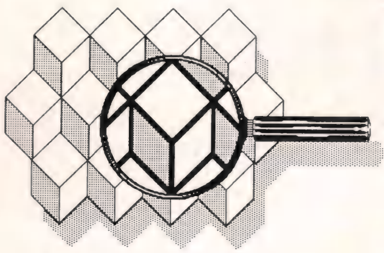

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Rational Systems has released Instant C, an incremental C compiler that pares down development time by processing only those parts of a program that have been changed. The compiler incorporates a full-screen editor; source-level debugger; object code linker; source code checker; run-time checker; and support for linking Lattice C, Versions 2.0 and 3.0, and Microsoft C, Version 3.0, object code and libraries. It runs on computers with MS-DOS or Concurrent DOS and costs $495. Reader Service No. 20.
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The Whitewater Group has released a new object-oriented programming language that incorporates Microsoft Windows. ACTOR is a fast and powerful programming environment that uses Pascal-style syntax. DDE (Dynamic Data Exchange) has been implemented for Microsoft Windows to allow for the simultaneous transfer of information between separate programs on the same computer. ACTOR runs on the IBM PC, PC/XT, or PC/AT and sells for $495. Reader Service No. 24.
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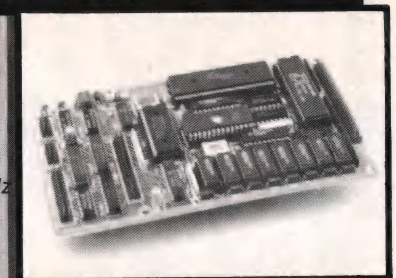

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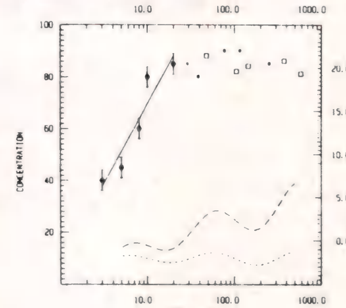

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(continued from page 141)

development system, including compiler, linker, integral editor, library source, assembler, and support. MS-DOS libraries include "peek and poke" throughout DOS memory, low-level DOS calls, and a debugger. The company also sells the editor's source code, which is written almost entirely in Modula-2, for $39.95. FTL Modula-2 costs $49.95. A package of FTL Modula-2 and the editor's source code costs $79.95. Reader Service No. 25.
Workman & Associates
1925 East Mountain St.
Pasadena, CA 91104
(818) 791-7979

Tools

PC/Assembler from **Computer Systems Documentation** is an interactive syntax-checking assembler for the Intel 80xx, 801xx, and 802xx and the NEC V20/30 processors. PC/Assembler is used to write assembler subprograms that can be invoked from a high-level language. It is not copy-protected and costs $99. Reader Service No. 26.
Computer Systems Documentation
P.O. Box 5478
Albuquerque, NM 87115

TurboMAGIC, a code generator for Turbo Pascal programmers, is now available from **Sophisticated Software**. TurboMAGIC includes a full-featured editor and the ability to create both pop-up and pull-down menu systems. The form image can be stored either as a typed constant or in a picture file. The software runs on the IBM, PC/XT, PC/AT, or compatible computers with 256K and is not copy-protected. It costs $99. Reader Service No. 27.
Sophisticated Software
6586 Old Shell Rd.
Mobile, AL 36608
(205) 342-7026

Expanding the IBM PC

Fort's Software has released NVRD, the Non-Volatile RAM-Disk, a software package designed to work with expanded memory hardware or with the company's Virtual Expanded Memory Manager (V-EMM). Combined with V-EMM hardware, NVRD provides the improved performance of a RAM disk with the nonvolatility of a hard disk. It runs on IBM PCs and compatibles with DOS 2.0—3.2, 192K RAM, a fixed-disk drive and fixed-disk adapter, and an EMS or V-EMM board. NVRD is available on its own for $49.95 or bundled with the V-EMM for $119.90. Reader Service No. 28.
Fort's Software
P.O. Box 396
Manhatten, KS 66502
(913) 537-2897

SOTA Technology has announced MotherCard 5.0, a plug-in card for IBM PC/XTs and compatibles that offers full AT-compatibility with all software written for the 80286, including protected mode operating systems. The on-board 1-megabyte RAM is all usable, and a DaughterCard connector is included that allows memory expansion to 16 megabytes. MotherCard 5.0 sells for $995. Reader Service No. 29.
SOTA Technology
657 N. Pastoria Blvd.
Sunnyvale, CA 94086
(408) 245-3366

An 8-megabyte memory expansion board for the IBM RT/PC is available from **Tall Tree Systems.** The JRAM-RT is a 32-bit board that makes use of the host motherboard's hardware to

(continued from page 143)

find and correct memory errors. It sells for $3,995. Reader Service No. 30.
Tall Tree Systems
1120 San Antonio Rd.
Palo Alto, CA 94303
(415) 964-1980

Micro Enhancer from **Everex Systems** is a 5-inch short card that makes EGA capabilities available for users with limited space in their IBM PC/XTs or compatibles. The board provides 640 × 350-pixel resolution graphics in 16 colors from a palette of 64 colors and is 100 percent compatible with the IBM Enhanced Graphics Adapter. To simplify using the board, Everex also supplies its EGMODE menu-driven software. Micro Enhancer costs $499. Reader Service No. 31.
Everex Systems Inc.
48431 Mimont Dr.
Fremont, CA 94538
(415) 498-1111

Personal Computer Support Group's half-slot speed-up board called the Breakthru 286 replaces the CPU of an IBM PC or PC/XT with an 80286 microprocessor faster than the one found in the 6-MHz IBM PC/AT. PCSG claims that the Breakthru 286 can beat the performance of other caching speed-up boards and that better performance can be expected in nearly all applications. The Breakthru 286 costs $595. Reader Service No. 32.
Personal Computer Support Group
11035 Harry Hines Blvd., #207
Dallas, TX 75229
(214) 351-0564

For the Mac

Datacopy Corp. has released two scanning systems—the Jet Reader and the Model 730—that produce high-resolution images containing 300 dots per square inch. Once scanned, images can be formatted for insertion into documents produced with a Macintosh desktop-publishing program. The company's MacImage software lets you control the scanner and manage, print, and view image files. The JetReader with MacImage software is priced at $2,250; the Model 730 sells for $3,250. Reader Service No. 33.
Datacopy Corp.
1215 Terra Bella Ave.
Mountain View, CA 94043
(415) 965-7900

THINK Technologies has introduced Lightspeed Pascal, a full ANSI Pascal. Lightspeed Pascal supports the Macintosh Toolbox and operating system and Apple's SANE extended numerics software. Compatible with Macintosh Pascal and Lisa Pascal, it runs on Macintosh computers with 512K RAM or more and is not copy-protected. It costs $125. Reader Service No. 34.
THINK Technologies Inc.
420 Bedford St.
Lexington, MA 02173
(617) 863-5590

Miscellaneous

Dynapro Systems has announced chronOS, a real-time multitasking operating system that lets you use standard DOS programming tools to write real-time applications. Source code is included for the console and sound generator drivers, language in-

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terfaces, and demo program. ChronOS runs on the IBM PC/XT or PC/AT and is tailored specifically for the iAPX86 microprocessor line. A U.S. site license costs $1,995, and a Canadian site license costs $2,495. Reader Service No. 35.

Dynapro Systems Inc.
1000 – 1200 W. 73rd Ave.
Vancouver, B.C.
Canada
(604) 263-2638

Alligator Transforms has released Prime Factor FFT, a fast Fourier transform subroutine library for the IBM PC, PC/XT, PC/AT, and compatibles equipped with an 8087 math coprocessor. The library can be called from any high-level language, and interface examples are provided in all languages. The library includes forward and inverse FFTs for single- and double-precision, floating-point, complex number sets. Users are not limited to radix2 data set sizes Prime Factor FFT sells for $159. Reader Service No. 36.

Alligator Transforms
P.O. Box 11386
Costa Mesa, CA 92627
(714) 662-0660

The Model E232-51 is a new in-circuit emulator from **Signum Systems** that provides real-time, transparant emulation for the 8031, 8051, and 8751 microcontollers. Connected to an IBM PC via the RS-232 interface, Model E232-51 features complete debugging facilities. Along with a command-driven user interface, the emulator provides users with windowing software and mouse support for controlling and monitoring program execution. Model E232-51 with 64K of overlay program memory is priced at $3,195. Reader Service No. 37.

Signum Systems
1820 14th St., Ste. 203
Santa Monica, CA 90404
(213) 450-6096

Lang-Allan has announced Version 2.00 of Bluestreak Plus, its communication package for the IBM PC, PC/XT, PC/AT, and compatibles. Bluestreak Plus is a full-featured software package that combines PC-to-PC communication and PC-to-mainframe communication with an open-architecture format for customization and modification at any level. The programming interface allows you to develop applications in many popular languages such as C, assembly language, Turbo Pascal, and dBASE. Bluestreak Plus 2.00 sells for $89. Reader Service No. 38.

Lang-Allan Inc.
2457 Aloma Ave., Ste. B
Winter Park, FL 32792
(305) 677-1539

Full-function simulation models of the Motorola MC68000 and MC68010 miroprocessors are available from **Quadtree** along with an extensive library of models of associated peripherals and an optional graphic microprocessor development system. The new models are part of Quadtree's Designer's Choice library, a library of software simulation models of standard, off-the-shelf digital devices. Call for prices. Reader Service No. 39.

Quadtree Software Corp.
1170 Rt. 22 East
Bridgewater, NJ 08807
(201) 725-2272

A 3½-hour C programming course is


C++

(continued from page 146)

available on video cassette from **Berkeley Decision/Systems**. The course is designed for expert programmers who want to learn C or people who are familiar with the language and want to learn more about it. The course includes a manual and more than 40 complete C programs to demonstrate the concepts presented in the video. *A Programmer's Introduction to C* is available for $400 in VHS or Beta formats. Reader Service No. 40.
Berkeley Decision/Systems
150 Belvedere Terr.
Santa Cruz, CA 95062
(408) 458-0500

Zoom Telephonics is now shipping a 2,400-baud version of its Zoom/Modem PC 1200. The new version has such additional features as demon dialing, audio input and output ports, and a high-speed 16450 UART for assured compatibility with IBM PC/ATs and compatibles. The Zoom/Modem PC 1200 can be upgraded to 2,400 baud with a plug-in board that costs $249. The Zoom/Modem PC 2400 ST sells for $499, and an XL version with more features costs $50 more. Reader Service No. 41.
Zoom Telephonics Inc.
207 South St.
Boston, MA 02111
(617) 423-1072

Access Associates has introduced Alegra, a memory expansion unit designed to add 512K of external memory to the Commodore Amiga. Alegra has a small footprint and allows for future expansion of up to 2 megabytes by replacing memory and configuration devices. The unit supports the auto-configuration architecture of the Amiga, and power is supplied by the computer at the expansion connector. Alegra sells for $379. Reader Service No. 42.
Access Associates
491 Aldo Ave.
Santa Clara, CA 95054
(408) 727-8520

Digitronix has released a low-cost Turbo upgrade kit called Veloz that brings IBM PC/XTs and compatibles up to the speed of a PC/AT. Veloz offers 100 percent compatibility with all major software packages and can be run with either the 8088-2 or V20 with no need to power down or replace the CPU. The price is $98. Reader Service No. 43.
Digitronix
2135 Junction Ave.
Mountain View, CA 94043
(415) 964-5103

PAX from **Baker & Rabinowitz** is a real-time multitasking executive for the IBM PC. It runs in concert with MS-DOS and requires no licensing or incorporation fees. The system kernel supports up to 32 concurrent tasks and is fully preemptive. The package is priced at $149.95. Reader Service No. 44.
Baker & Rabinowitz Inc.
3869 Kilbourne Ave.
Cincinnati, OH 45209
(513) 871-0886

CodeWorks is a new magazine for

people interested in BASIC programming under MS-DOS, TRS-DOS, or CP/M. Each annual subscription covers all six issues of the calendar year and costs $24.95. Interested readers can write for a free sample issue. Reader Service No. 45.
CodeWorks
Sample Copy Offer
3838 South Warner
Tacoma, WA 98409

A system modeling tool called Performance Analysis Tool Box is available from **Computer Technology Associates.** The package simulates a variety of centralized or distributed computer architectures, allowing designers to investigate broad ranges of use patterns in a hypothetical system. It's $10,000 for the IBM PC. Reader Service No. 46.
Computer Technology Associates
7927 Jones Branch Dr., #600W
McLean, VA 22102

Microsoft Corp. has announced the availability of extensions to the MS-DOS operating system that support the use of CD ROM disk drives with personal computers. The MS-DOS CD ROM extension consists of two software modules—a hardware-independent program and an installable device driver that must be customized by each manufacturer to work with its own hardware. Microsoft will supply the hardware-independent program—the DOS extension that will handle the much higher capacity of the CD ROMs—plus a sample device driver and documentation.

With the new software, PCs running DOS 3.1 or 3.2 can read data from any CD ROM disk that is compatible with the High Sierra Group file format proposed at the National Computer Conference in May 1986. Microsoft will license these extensions directly to CD ROM drive manufacturers, and they are available only on an OEM basis. Reader Service No. 47.
Microsoft Corp.
16011 N.E. 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
(206) 882-8080

Practical Peripherals is now offering a stand-alone 1,200-bps modem, the Practical Modem 1200 SA. It is fully Hayes-compatible, includes auto-dial/auto-answer capabilities, supports virtually all communications software, and includes an upgrade path for a programmable enhancement card. The suggested retail price of the modem is $239. Reader Service No. 48.
Practical Peripherals
31245 La Baya Dr.
Westlake Village, CA 91362
(818) 991-8200

DogStar Software has announced subVol, a disk subvolume manager that brings PC-DOS- and ProDOS-like subdirectories to Apple Pascal DOS. SubVol works on any Pascal formatted disk device and allows hard-disk users to format directly and install a complete set of subvolumes with Apple Pascal.

The program works by attaching virtual disk drivers to the unused disk units in an Apple Pascal system. The virtual disk drivers cause a portion of any real disk to behave as though it were a volume in itself, including a subdirectory plus any files in that subvolume. The product runs on Apple II computers with Apple Pascal (Version 1.1, 1.2, or 1.3). The price is $34; with source code it costs $75. Reader Service No. 49.
dogStar Software
P.O. Box 302
Bloomington, IN 47402
(812) 333-5616

Instant Replay by **Nostradamus** is a demonstration development toolkit that generates tutorials, demos, presentations, menu systems, and timed keyboard macros. It is not copy-protected and runs on the IBM PC, PC/XT, and PC/AT. The product is priced at $89.95. Reader Service No. 50.
Nostradamus
5320 South 900 E, Ste. 110
Salt Lake City, UT 84117
(801) 261-0769

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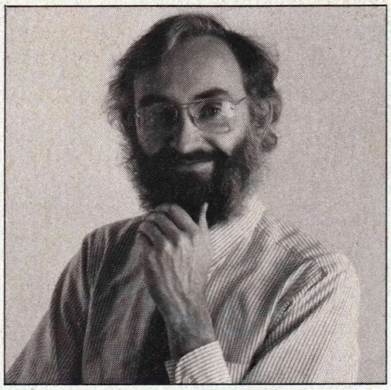

Yes, I was kidding about BASIC in November. BASIC, on the other hand, seems to be getting serious, with such features as advanced structure constructs, new data types, labels for branching, internal and external subroutines, multiline and decision-making functions, recursion, libraries, modules, better file I/O, low-level and DOS access, sophisticated string manipulation, and advances in portability and standardization. And now that Borland is bringing out a Turbo BASIC, competition may hasten the maturation process.

Granted that the Turbo Pascal-Turbo BASIC-QuickBASIC type of rapid-interaction compiler is not a reasonable substitute for C and assembly language in a major software development task, it does seem to be finding a place in certain kinds and stages of development. The fact that both Borland and Microsoft have interactive C compilers in the works suggests that they think so—it's hard to believe that they expect to sell C to Sunday-afternoon programmers. But it's more significant that there seems to be a growing interest in enlarging the programmer's toolkit, offering more options in development environments, and offering tools that make the programmer more productive and efficient.

Good programming is often artful. Any engineering discipline is like art in that both bring new things into the world and rely on skill and serendipity and unlike art in being more concerned with result than with process. In fact, one goal of engineering is to refine processes, automating portions in order to free the engineer to be artful at another level. Does software development do this?

If not, it should. I recently reread Robert Heinlein's *The Door into Summer* and was struck by how convincingly and appealingly Heinlein portrayed the engineer as an artist whose very art provides the means to improve his brush. If software development really is an engineering discipline, it needs more Waldoes and Drafting Dans, more tools to automate the repetitive processes.

John Backus does not believe that programming is an engineering discipline yet, arguing that it is still too much an art. (See "From Function Level Semantics to Program Transformation and Optimization," *Lecture Notes in Computer Science* 185 [1982].) Solving the software crisis, he maintains, requires that it become an engineering discipline.

Parallel processing is the wave of the future, right?

That was the gist of Gordon Bell's keynote address at the Fall Joint Computer Conference in Dallas in November. The promise of parallelism may have been overstated in some areas. Two former advocates of parallel design for database machines, Haran Boral of the Israel Institute of Technology and David DeWitt of the University of Wisconsin at Madison, have come to believe that we should not build database machines that attempt to maximize throughput via massive parallelism. The problem, they contend, is that I/O bandwidth per gigabyte of storage is decreasing rapidly and that it is the I/O bandwidth issue that will be the bottleneck in database machines. "Unless mechanisms for increasing the bandwidth of mass storage devices are found, highly parallel database machines are doomed to extinction," they conclude in "Database Machines: An Idea Whose Time has Passed?"(*Database Machines*, H. O. Leilich and M. Missikoff, eds. [Berlin: Springer-Verlag, 1983]).

Those of you who live in California may have discerned a bit of chauvinism in Massachusetts' claiming to be the Software Capital of the country. Those of you who do not live in California probably detected even more chauvinism in the recent passage of a ballot proposition making English California's state language. No doubt the California legislature will soon be turning arroyos and mesas into gulches and hills just as the French, who invented chauvinism, have for years been kicking Americanisms out of *la langue Française*.

My cousin Corbett is cursing what he calls "egotistical linguistic chauvinism." He had worked hard on an alternative proposition that he thinks is much more appropriate because it actually addresses a real problem. Unfortunately, it did not get on the ballot in 1986, but Corbett plans to be more successful in 1988 and is starting to organize now. His plan is to replace English with C as California's language, and he invites your participation. C, he points out, is capable of expressing anything anyone could ever need to express, and the time has come for fanatical supporters of minority languages to put aside their pride, accept the inevitable, and end the Babel of incommensurable dialects once and for all.

"*Des egos, et encore des egos.*"—Ed Faber, in *Silicon Valley*, the French edition of *Fire in the Valley* by Paul Freiberger and me.

Michael Swaine

Michael Swaine
editor-in-chief

TALK OF THE TOWN

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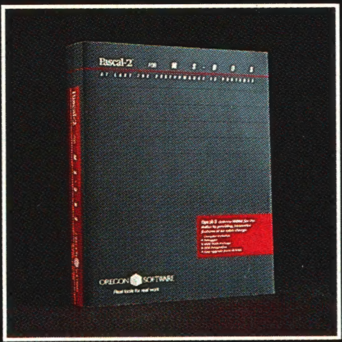

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> *Jerry Pournelle, BYTE Magazine*
>
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> *Michael Covington, PC Tech Journal*"

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